Referent: Prof. Dr. med. Carl Henschen

ON THE LEECH
AND ITS USE IN MEDICINE

INAUGURAL DISSERTATION

presented to the

Faculty of medicine of Basel

by

PAUL PETER WESTFALL

from Brooklyn, New York City

to obtain the

DEGREE OF DOCTOR OF MEDICINE

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Von der Medizinischen Fakultät genehmigt auf Antrag von
Herrn Prof. Dr. *C. Henschen*

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I would like to take advantage of this opportunity to express my gratitude to the Medical Faculty of Basel for giving me the possibility of completing my medical education.

I also feel indebted to all Professors and Doctors of the faculty who have given me instruction.

I want to thank Prof. *Geiger-Huber*, Professor of Botany in Basel, for the permission to keep a number of leeches in a tank in the botanical garden of the University.

Historical survey

In Proverbs Chapter 30 verse 15 it is written עלוקה Aluka which has been translated as leech. Luther in his translation of the Bible gives the word as Eigel, a modified form of Egel the German word for leech. On the other hand Schultens in his commentary explains the word to mean "monstrosissima quæque". Simonis in Lexicon Hebraicum gives it as "monstrum tetrum". Bochart in Hierozoicon explains the Hebrew Aluka and the Arabic word Aluk to mean Fatum. The Arabic Aluk is derived from علق Alaka to attach, since in the conception of the Arabs every one has his Fatum attached to him. Aluk in Arabic has the sense of an evil spirit in the form of a female monster which haunts wierd spots an graveyards. The Greek Ἔμπουσα would correspond to it. Herder believes the Haluka to be the *Μοῖρα* or *Λάχεσις* of neareastern poesy, while Gesenius considers it to be a product of its superstition (*Brandt*).

According to *Daremberg* the triple Hecate *Ἑκάτη τρίμορφος, τριπρόσωπος* a chtonic diety was thought by the Greeks to send apparitions of which the Empousa was one and Antaia was the other. Aristophanes presented the Empousa as inclosed in a blood filled bladder. Because the Empousa was supposed to have feet with hoofs as those of a donkey she is also called *ὀνοσκελίς*. According to Lukian the *Ὀνοσκελέαι* were beings in the appearance of women with asses hoofs instead of feet, resembling women of loose habits in that they were painted and seduced men to come to them and after making them drunk would fall over them, after they were tired out and asleep in bed. The Real Encyclopedie of Pauly mentions a third apparition which the triple Hecate used to send Rhea, *Ῥέα*. The fact that Hecate was conceived of in a triple form and was believed to send three different types of monsters could possibly offer a better understanding of the Bible verse in the Proverbs. In this case the word Aluka would have the sense as understood by *Simonis* and *Bochart*. Alak does however mean leech in present day Arabic and is the word used to designate leeches commonly found in the Nile.

Herodotus mentions leeches in II. 68,

«ἅτε δὴ ὢν ἐν ὕδατι δίαιταν ποιεύμενον, τὸ στόμα ἔνδοθεν φορέει πᾶν μεστὸν βδελλέων»

and also

«ὁ τρόχιλος ἐσδύνων ἐς τὸ στόμα αὐτοῦ καταπίνει τὰς βδέλλας»

Scriban and *Autrum* in the Handbook of Zoology of Kükenthal, vol. 2, part 8, p. 321, are of the opinion that the leeches found in the crocodiles' jaws are the Hæmeteria fimbriata (*Johansson*) and the Ozobranchus quatrefagesii Poirier et de Rochebrune. The bird Trochilus of Herodot is the Pluvianus ægypticus Linnæus. According to *Moquin-Tandon* the leech mentioned by Herodot is the Limnatis nilotica. Hippokrates does not mention the use of leeches for therapeutic purposes. However he does say in Prorrheticon II. 17 (Littré IX 45), that if a patient has blood in his pharynx, without having headache, cough, fever, or pains in chest and back, one has to examine the pharynx for an ulcer, or as to whether a leech may have attached itself there. According to *Huber* the pupils of Erisistratus and Herophilus must have used leeches long before Nikander of Kolophon. Cupping was widely practiced by the ancients and it is logical to assume, that leeches were used to suck out blood in places where cupping could not be successfully performed. It is of interest to note, that the instrument most commonly used by the ancients for cupping was made of bronze. A witness to this is Oribasius in his excerpt from Antyllus "... l'usage des ventouses en bronze est le plus repandu" (translation by *Daremberg*). Ventouse is the French word for any sort of suction cup, the cupping glass or any instrument used for cupping. The instruments depicted in "Œuvres d'Oribase" by *Daremberg* were found in Herculanum and Pompeii in the course of excavations there. Thirteen of these cupping instruments were found in Pompeii and Herculanum. One of these objects was over 4 inches in height, others were also of considerable size. The publication of *Vulpes* should be consulted for illustrations of these and of surgical instruments found in Pompeii and Herculanum.

Nikander of Kolophon mentions leeches in his Alexipharmaka and in Theriaka. In Alexipharmaka, Nikander mentions the possibility of an ingestion of a leech, while drinking water and recommends to drink a solution of salt as a remedy (*Huber*). Themison, the methodic from Laodikea used leeches for therapeutic purposes very frequently, as seen from the works of Cælius Aurelianus. "Plurimas etiam fronti sanguisugas apponit, atque humeris et temporibus capitis, quod est contra sectae rigorem." This practice of using leeches in cases of head disorders was apparently not approved of by the other methodics. Aretæus of Cappadocia used leeches for "morbus cœliacus", disorders of the liver and satyriasis (*Huber*). Plinius discusses the accidental ingestion of leeches in a number of places in his books. Also that occassionally after the application of leeches for therapeutic purposes the head of the leech is left in the wound, this leading to an incurable sore. So in XXXII, p. 122–124: "Diversus hirudinum, quas sanguisugas vocant, ad extrahendum sanguinem usus est ... Aliquando tamen relinquunt adfixa capitis, quae causa vulnera insanabilia facit ...». Menemachus (see Œuvres d'Oribase, tome II, p. 72, ed. Daremberg, Paris, 1854) translated from the French gives the following directions: "One applies the leeches to the diseased

parts themselves, or to adjacent parts which are free from grease, because grease spoils their appetite, for this purpose one places them into a narrow ... similar instrument. The number must be proportioned in regard to two circumstances to the volume of the affected part and to the seriousness of the malady. ... Should they not bite, one scarifies superficially that part of the body, where one intends to apply them, because once they have tasted blood they seek more with avidity". Soranus of Ephesus used leeches very extensively as is to be judged from Cælius Aurelianus (400 A.D.), who has made the works of Soranus available to us to a considerable extent through his recensements of Soranus. Cephalea or headache, congestion of the liver and diseases of the bladder were treated by Soranus with leeches. In Chron. I. 1. § 13 on headache (cephalea) is said "Atque ita sanguisugæ apponendæ (i.e. ad caput novacula rasum), quas hirudines appellamus, et magis si locorum inæ qualitas cucurbitæ non fuerit capax, quo inhærere minime possit" (quoted from *Huber*). In Chron. V. 4 (vesicæ passiones) "et hirudinem appositio, atque embasis adhibenda ex calida et oleo". Celsus in Lib. V. cap. 27 "si sanguisuga epota est, acetum cum sale bibendum est." In editions of Galenus we find a short treatise on leeches, derivation and cupping, since the text practically is identical in wording with excerpts from Antyllus passed on to us by Oribasius, the treatise most probably has not been written by Galenus.

Antyllus the surgeon, who lived in the third century after Christ, in the excerpt from him as given to us by Oribasius in his Medical Collection, book VII, Chapter 21 (ka') recommends to rub the spot intended for their application, or to scarify the same. The purpose of these measures is evidently to produce hyperemia, since he also recommends the use of fomentations. In case one does not have a sufficient number of leeches on hand one can nip off the caudal end of the leech with a pair of scissors, while it is in the process of sucking blood. By the use of this device it is possible to have the leech suck out a greater amount of blood. To force the leech to relinquish its hold one applies salt, raw soda or cinders to the sucker. Antyllus also counsels to pick up the leech with a sponge, wiping off some of the slime. It is also advisable to apply a suction cup to the site of the leech bite, after the leech has relinquished its hold, having had its fill. According to Antyllus it is advantageous to use leeches, there where one can not use the cupping glass by reason of the configuration of the body or because of the smallness of the member.

In later times Theophanus Nonnus, Paulus of Aegina, Aetius of Amida and Ioannes Actuarius (A.D. 1290) write on accidentaly ingested leeches and recommend remedies for such occasions. Arnaldus de Villanova advises to use leeches on wounds produced by the bite of a mad dog and to follow up the leech treatment with cupping (quoted from *Brandt*). A. Benedictus recommends them against vertigo and rheumatic headache. Horatius Angenius

says that one should use leeches in place of venesection in the treatment of children. H. Mercurialis uses leeches frequently, but believes that leeches suck out only the more easily flowing blood, while they do not evacuate the more viscous portion. Mundelle advises to use leeches in inflammation of the legs and in the treatment of hemorrhoids. Zacutus Lusitanus and especially *Sennert* popularized the use of leeches. *Price* wrote a "Treatise on the utility of sanguisuction or leechbleeding", London, 1822.

In old Chinese medical literature we find leeches first mentioned in the Erh Ya. The Shen Nung Pen Ts'ao Ching which was probably compiled in the eastern Han Dynasty A.D. 25 to A.D. 219 says of leeches in Vol. 4, p. 12: "Use: For removing stagnant and coagulated blood, in cases of amenorrhœa, blood stasis, sterility and to facilitate the passage or urine." The Erh Ya Yin T'u was compiled in the western Han Dynasty 206 B.C. to A.D. 25. Ch'en Tsang Ch'i is quoted as follows by *C.C. Tang* and *R. Höppli*: "More than ten leeches are applied to suck on the diseased part; till the flesh turns pale and the skin becomes wrinkled, the effect will be produced ... after the skin of man has been washed clean, a leech put into a bamboo tube is applied to the skin. After a while, through biting and sucking, the animal becomes swollen with blood and detaches itself. Then another hungry one is used again." The chinese also used leeches internally to a great extent. There are many references in chinese medical literature however, to the fact that the leeches are to be thoroghly cooked, fried or burned to ashes before they are to be used as medicine. There is discussion among the authors to fact that if leeches are improperly, i.e. insufficiently, exposed to the action of heat they will cause disease if taken internally. It is assumed by some medical writers that leeches although cut to small pieces would come to life again and grow in the body if swallowed. So Ch'en Tsang Ch'i: "... They must be cut into pieces and heated slowly over fire until their color turns yellow, so as to ensure thorough process of preparation ..."

Of interest is the use of leeches for cosmetic purposes by the Chinese. Hair that had turned yellow by reason of age was dyed to a dark color again through the use of a prescription one of the ingredients of which were leeches burned to ashes. The prescription was carried on from one encyclopedia to the other throughout the centuries. It is given in the Sheng Chi Tsung Lu edited during Cheng Ho of the Sung Dynasty, A.D. 1111 to 1115. It is also mentioned in the new Ta Teh edition during the Yuan Dynasty A.D. 1300, also in Sheng Chi Tsung Lu Ch'uan Yao as collected by Ch'en Liu in the Ch'ing Dynasty. It must be assumed that it was frequently used and some positive results were obtained. It is also to be noted that *Plinius* gives prescriptions containing ashes of leeches to be used for cosmetic purposes in book XXXII, 67, 76, 136.

For exact references of old chinese literature on the use of leeches in Chinese medicine consult *R. Höppli* and *C.C. Tang* from whose publication

in the Chinese Medical Journal these references of the use of leeches by the Chinese were taken.

The development of observation and of natural science may be demonstrated by a retrospect of some of the more important landmarks. The ancients knew to distinguish only a small number of leeches (*Moquin-Tandon*). *Rondelet* in 1554 was one of the first to notice that the medicinal leech had three small jaws. *Redi* in 1684 observed that the digestive system of marine leeches differed from that of the medicinal leech. *Redi* also recognized that the Hirudo medicinalis had 9 pairs of testicles. *J. de Muralto* published the oldest known anatomy of the medicinal leech in 1685. The mechanism of the jaws was taken into cognizance by *de Muralto* and the greater part of his descriptions are precise (*Moquin-Tandon*). In his "De Piscibus" *Rondelet* described and gave an illustration of a marine leech. This animal is the Pontobdella muricata (Linnæus). *Gesner* published a none too good a depiction of the Hirudo medicinalis Linn. in his "De piscium et aquatilium animantium natura" in 1558, calling it Hirudo major et varia (*Moquin-Tandon*). In 1602 *Aldrovande* published a review of everything known to him about leeches. According to *Moquin-Tandon* he did not use much judgement in the selection of his material. He does add however three new species. The Rossaglen or the horse leech (Hæmopis sanguisuga Linn.), the Hirudo alba or the leech of sweet water fishes (Piscicola geometra) and the Hirudo tenuior, the mousetail leech, Sangsue de queue de souris as called by *Moquin-Tandon* (Herpobdella octoculata).

The beginning of the 18th century brought about greater progress with observation becoming more precise. *Roesel de Rosenhof* in his "Der monathlichen herausgegebenen Insecten Belustigung, etc.", Nüremberg 1747–1755, described a small leechlike worm found in the gills of the crayfish (Branchobdella astaci Odier). *Tremblay* in his "Mémoires pour servir à l'histoire d'un genre de Polypes d'eau douce, à bras" described a leech of unusual transparency in 1744, *Hill* gave the description of another in 1752 and *Thorbern-Bergmann* described a third in 1756. All of these leeches were according to Moquin-Tandon Glossiphonia. The nomenclature has changed since the days of *Moquin-Tandon*. In the nomenclature of *Moquin-Tandon* the transparent leech of *Tremblay* is called the Glossiphonia heteroclita. A diagnosis of the animal is given by *Moquin-Tandon* on pages 358 and 359 of the second edition of his monography on leeches. There also in the synonymy it is stated that the animal had been called Hirudo heteroclita by Linnæus in the edition of 1761 of the Fauna Suecica as No. 2085.

The leech described by Hill is called Glossiphonia sexoculata by *Moquin-Tandon*, while Autrum in the Handbuch der Zoologie of Kükenthal, edited by Krumbach, in volume 2, part 8 of this voluminous publication in the chapter on the classification of hirudinea p. 346 gives the valid name for this leech as Glossiphonia complanata (Linnæus 1758). The third leech, the

one described by *Thorbern-Bergmann* is called Glossiphonia bioculata by *Moquin-Tandon* but is given as Helobdella stagnalis (Linnæus 1758) by Autrum in the handbook of zoology of Kükenthal, the section on hirudinea in that handbook being published in 1934.

In the case of the second leech at least the generic name had been retained, which is not the case with the third. It must be made quite clear that a stable nomenclature is indispensable for mutual understanding and progress.

The "Systema Naturae" of Linnæus carries the date 1758 and is a turning point in natural history. The genus Hirudo of Linnæus comprised worms with an elogated body, which used for locomotion widened out mouth and tail. "Corpus oblongum, promovens se ora caudaque in orbiculum dilatandis." Linæus differentiated 9 species of the genus Hirudo. The Hirudo indica, H. medicinalis, H. sanguisuga, H. octoculata, H. stagnalis, H. complanata, H. heteroclita, H. geometra and the H. muricata. Linnæus made no differentiation between the marine leech described by *Rondelet* in 1554 and a marine leech described by *Baster* in 1760, including them both in the 12th edition of his Systema naturae of 1767 into the 9th species of the marine leeches, H. muricata. The leech described by *Rondelet* was undoubtedly according to *Moquin-Tandon* and the modern teatise of *Scriban* and *Autrum* of 1934 in the Handbook of Zoology, the Pontobdella muricata. The leech described by *Baster* differed somewhat from the marine leech of *Rondelet*, as stated by *Moquin-Tandon.*

Moquin-Tandon also writes that it was actually *Ray* in his "Historia insectorum", London, 1710, who established the genus Hirudo. *Ray* however included among the leeches the "Sangsue limace" of Réamur, which was found later to be not a leech, but the sheep liver fluke, the Fasciola hepatica. The genus Hirudo of *Ray* comprised the medicinal leech or the leech of the ancients or of Gesner as also called by *Moquin-Tandon*, the Rossaglen or horse leech (the present day Hæmopis sanguisuga), the leech of sweetwater fishes of Aldrovande (the present day Piscicola geometra) and the unfortunate sheep liver fluke, the Fasciola hepatica. When Linnæus established his genus Hirudo he excluded the fluke.

Attempts were soon undertaken by investigators to subdivide the genus Hirudo as established by Linnæus. The genus Pontobdella was created by *Leach* in 1815 for the marine leeches. The genus Glossiphonia by *Johnson* for leeches possessing a tube or trumpetlike appendage in the region of the anterior sucker and a flat or slightly concave ventral surface of the body. *Dutrochet* gave his own name to a genus of exceedingly voracious habits, calling them Trocheta in 1817. Between 1815 and 1817 *Oken* made the attempt to call the Pontobdella of Leach with the name of Gôl, the leeches parasitizing sweetwater fishes as Ihl (Piscicola of Blainville). He also tried to form the genera Phylline and Helluo. These changes were not recognized later because they violated the rules of priority and because they were not

derived from either greek or latin. *Johnson* tried to change the generic name of Glossiphonia, which he himself had created in 1816 to Glossopora (*Moquin-Tandon*). Although this attempt was undertaken only a year later, in 1817, the change proposed by *Johnson* was not adopted. Article 32 of the international Code of zoological Nomenclature forbids the change or rejection of a generic or specific name once established through publication, even by its author. The Rules and Recommendations of the International Zoological Nomenclature were published in 1926 by the International Commission on Zoological Nomenclature. As quoted from *Craig* and *Faust* "Clinical Parasitology", page 38: "The International Rules of Zoological Nomenclature are a concerted attempt on the part of zoologists the world over to develope uniformity in the use of technical names applied to animal forms", and further on "the International Rules alone preserve zoological nomenclature from utter confusion."

A goodly number of the Rules and Recommendations of the present day Code have been developed, as a result of experiences of the confusion, which existed prior to their establishment. This confusion necessarily raises its head the moment these rules are disregarded. Some of the following will serve as evidence for the above. *Moquin-Tandon* writes on page 19 of his Monography, that in 1817 *Savigny* divided the genus Hirudo of Linnæus into 7 genera. These genera were Branchellion, Albione, Bdella, Sanguisuga, Hæmopis, Nephelis and Clepsine. Albione was the genus Pontobdella created by Leach in 1815, Nephelis corresponded to Helluo of Oken, while Clepsine was the genus of Glossiphonia of *Johnson*, established by him in 1816. Furthermore *Savigny* changed the generic name of Hirudo of Linnæus to Sanguisuga.

Some authors followed *Savigny* in his changes. *Moquin-Tandon* in the first edition of his Monography on leeches of 1826 adopted the designation Sanguisuga for the genus Hirudo. He admitted the mistake he made in the second edition of his Monography of 1846 on page 21. *Brandt* and *Ratzeburg* in the "Medizinische Zoologie" of 1829 call the genus of medicinal leeches Sanguisuga. *Lamarck* using partly a manuscript furnished to him by *Blainville* retained the genera of Pontobdella of Leach and of Phylline of Oken, but changed the nomenclature of Oken for leeches parasitizing sweetwater fishes from Ihl to Piscicola and of Phylline to Erpobdella. *Lamarck* also changed the spelling of *Dutrochet's* Trocheta to Trochetia (*Moquin-Tandon* p. 20). In 1828 *Blainville* changed the generic names Branchellion of *Savigny* to Branchiobdella, the Glossiphonia of *Johnson* to Glossobdella, the Hæmopis of *Savigny* to Hippobdella, the Hirudo of *Linnæus* to Jatrobdella, the Limnatis of *Moquin-Tandon* to Paleobdella, the Aulastoma as given by *Moquin-Tandon* in 1826 to Pseudobdella (Aulostoma gulo of *Moquin-Tandon* is identical with Hæmopis sanguisuga [*Linnæus*], according to *Scriban* and *Autrum*, Handbook of Zoology, vol. 11, part 8, p. 174), the Nephelis of

Savigny to Erpobdella (the valid name for the genus Nephelis is Herpobdella de *Blainville* 1818, *Blanchard* 1894, according to *Scriban* and *Autrum*), his own Piscicola to Ichthyobdella and the Phylline of Oken to Epibdella. *Blainville* also changed the genus Trocheta of *Dutrochet* to Geobdella (*Moquin-Tandon*, p. 22).

These few examples of arbitrary changes of nomenclature, should make the confusion that arises from such changes evident.

On the other hand the discovery of the trout leech in 1816 by *Johnson*, the Hirudo troctina, a beautifully green leech from northern Africa and of Branchiobdella astaci in 1819 by *Odier*, a leech parasitizing the crayfish may be cited as important milestones on the road of progress of natural history. *Odier* also established the genus Branchiobdella in 1819 (*Moquin-Tandon*).

Spix, *Kuntzmann* and *Bojanus* made contributions toward the development of knowledge of the anatomy of leeches between 1813 and 1827.

In England *Home* published his "Lectures on comparative anatomy", in 6 volumes between 1814 and 1828. *Johnson's* publication "A treatise on the medicinal leech, including its medical and natural History with a description of its anatomical structure", London, 1816, is the first scientific work written in the English language devoted exclusively to Hirudinea. *Johnson* was the first to notice, that the fused paired ganglia, united by twinned nervecords, i.e. the ganglionic chain, were enclosed in the ventral blood sinus.

In William H. Keating's "Narrative of an Expedition to the Source of St. Peter's River, Lake Winnepeek, Lake of the Woods, etc.", Major's Long second Voyage, published in Philadelphia in 1824, it is stated on page 150 of the second volume: "Mr. Say observed in the small lakes a number of leeches, among which four new species have been established."

On page 266 of vol. II of the same book is given "Class Vermes. Order Cryptobrachia. Hirudo. 1. *Hirudo parasitica.* A yellow vitta before, quadrate marginal spots each side; beneath with about eleven longitudinal lines; ocular points two." In the description it is stated that the leech adheres to the sternum of the inferior shell of tortoises.

2. *Hirudo lateralis.* "Dull livid with a rufous line each side; ocular points six ..." "This species occured in most of the small lakes on the height of land, between Rainy Lake and Lake Superior."

3. *Hirudo marmorata.* "Blackish, varied with dirty whitish; ocular points six."

4. *Hirudo decora.* "Body livid with a dorsal series of twenty-two small red dots, and a lateral series of the same number of black dots of a similar size." "This species is much smaller than either of the preceding and comparatively rare. It occured in Vermillon Lake."

The leeches described by *Say* and classified by him, in 1823, correctly in the genus Hirudo, as established by *Linnæus*, have been reclassified in later

times. The leech called Hirudo decora by *Say* is the Macrobdella decora (*Say*) of present days. The genus Macrobdella was established by *Verrill*. The Macrobdella decora (*Say*) is the leech commonly used in the United States in therapy (*Scriban* and *Autrum*). Of interest is the fact that *Say* classified the genus Hirudo in the order of "Cryptobranchia".

In 1827 *Blainville* gave a summary of things known on the anatomy and physiology of Hirudinea up to his time in the "Dictionnaire des sciences naturelles".

The "Medicinische Zoologie" of *Brandt* and *Ratzeburg* appeared in its first edition in 1829. It is a most remarkable book with an appended atlas of copper prints and illustrations in color. It gives a number of drawings on the anatomy of the medicinal leech. *Brandt* published a monography on the anatomy of the medicinal leech in 1833.

The second edition of the monography on Hirudinea by *Moquin-Tandon* appeared in 1846. According to *Scriban* and *Autrum*, the editors of the section on Hirudinea in the Handbook of Zoology of Krumbach, one of the most complete works on zoology in the German language, no publication has brought a summary of all the known species of Hirudinea, giving their characteristics and physiology and bringing knowledge with regard to them up to date, after the monography on them by *Moquin-Tandon* in 1846. A tremendous amount of information, some of it very detailed, has been collected since the time of *Moquin-Tandon* on Hirudinea, but it has not been moulded into an entiety, which the monography of *Moquin-Tandon* did accomplish in its time.

It must however be pointed out that a number of gross misconceptions existed about the anatomy and physiology of leeches up to the beginning of the past century. In the 18th century *Dillenius* had propagated the conception that leeches breathed through their mouths. *Morand, du Rondeau* and *Bibiena* had similar notions. In 1805 *Sorg* believed that leeches had abdominal tracheæ. *Thomas*, who otherwise was a very keen observer and who made some important observations, was misled to believe that leeches had a respiratory system. *Johnson* considered some Hirudinea to be viviparous. *Carena* was of the opinion that the Glossiphonia gave birth to living young. *Mayor* and *Filippi* showed that *Carena* was in error (*Moquin-Tandon*, p. 170). Very little was known on the mode of reproduction of Hirudo medicinalis prior to the publications of *Noble* and of *Charpentier* in 1822 and in 1824 respectively. These two authors were the first to publish information to the fact that the Hirudo medicinalis deposited its eggs in cocons on the banks of small rivulets, pools and swamps which it inhabits.

In more recent days *C.O. Whitman, Apáthy, R. Blanchard, Johansson, J.P. Moore, Kowalewsky, W.E. Castle, W.L. Castle, Brumpt, Pinto* and *Weber* contributed to our knowledge of the anatomy, taxonomy, physiology and life habits of leeches to name just a few.

Anatomy and Physiology

The number of somites of Hirudo medicinalis Linnæus is 34. The somites of the anterior and the posterior ends of the animal have undergone fusion. The somites of the equatorial region on the other hand consist of the full number of annulations characteristic for the genus. The anterior or cephalic region is composed of the protomerite and of the next 4 partially fused somites. The somites I and II each carry a pair of eyes, or eye-spots as called by *Craig* and *Faust*, and are represented by single annulations. Somite III is composed of 2 and somite IV of 3 annulations or rings. Somites V, VI, VII and VIII form the preclitellar, while somites IX, X and XI form

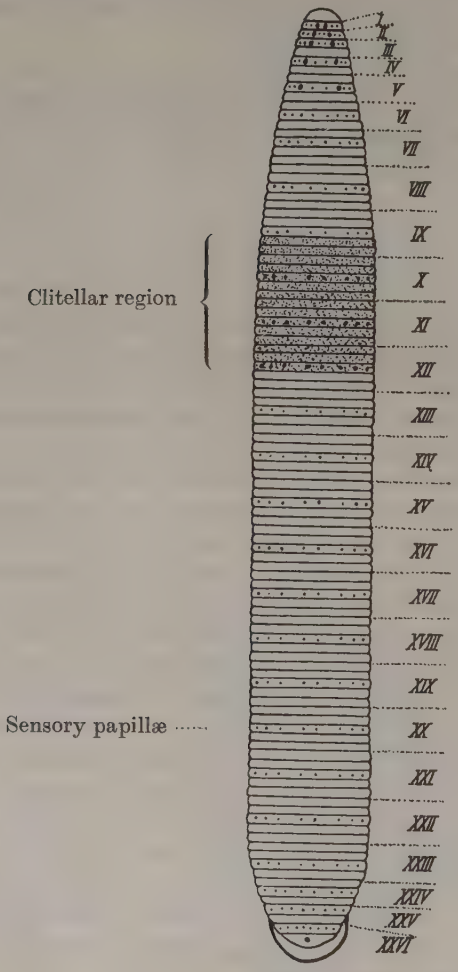


Fig. 1.

the clitellar region. The clitellar region swells during the mating period of the leech. The ducts of the clitellar glands emerge in this region, the secretion of these glands is used by the animal to produce the cocons into which it lays it's eggs. The male genital apperture is found between the 30th and the 31st annulation of the Xth somite, the female opening between the 35th and 36th ring of the XIth somite. The equatorial region extends from the XIIth to the XXIInd somite inclusive. Somite XXIII has 3, somite XXIV and XXV 2, somite XXVI 1 annulation. The anal segmentation is the somite XXVII. The posterior sucker is composed of the last 6 fused somites. With the protomerite this gives us a total of 34 somites. The sum of annulations of the medicinal leech is 101 (*Scriban* and *Autrum*, and *C.O. Whitman*).

The sensory papillæ are arranged in 8 rows on the dorsum of the animal. The paramedian sensory papillæ of the first 5 somites on annulations 1, 2, 3, 5 and 8 are modified to eye-spots. The developed sensory papillæ are located on one annulation the respective somite. This annulation is the median annulus of the somite (*W.L. Castle*). The conception that the ring with the more fully developed sensory papillæ is in the middle of the somite is corroborated by the internal segmentation, especially by the metamery of the nervous system, which corresponds to the external location of the papillæ on the median ring of the somite. There is also evidence to this in phylogenesis.

The Hirudinea are descended from the Lumbriculidæ, which are also the ancestral family of the Neoligochæta. The Lumbriculidæ possess a number of characteristics, which are common to the Archioligochæta. The genera Teleuscolex and Lamprodrilus of the family of Lumbriculidæ, apparently are the most ancient. The seminal pouches or receptacula seminis of these two genera have a posterior position in relation to the other reproductive organs, as is also the case with the seminal pouches of the Phreodrilidæ a family of the Archioligochæta (*Michaelsen* in Krumbach, Section 8, p. 88). The Hirudinea the second order of the Clitellata may be regarded as Lumbriculidæ, with further developed special characteristics, already preformed in the order of Oligochæta, as an adaptation to their predatory ways (*Michaelsen* in Krumbach, Section 8, p. 92).

The genus Agriodrilus, with the single known species Agriodrilus Michaelsen, is the connective link between the Oligochæta and Hirudinea. The Agriodrilus is the only oligochæte whose testes lie further towards the caudal end of the animal than the ovaries, a characteristic of Hirudinea. Furthermore the body cavity of the Agriodrilus is reduced from the 2nd to the 11th metamere. The reduction of the body cavity and its replacement with connective tissue is also a characteristic peculiar to the hirudinea. The gut of this oligochæte, in the region of the mentioned metameres, showes an enormous development of musculature. The gut is modified to a pharyngo-œsophageal muscular crop, whose lumen is triangular in shape as in the

genus Herpobdella de Blainville (also known as Nephelis) of the hirudinea (*Michaelsen* in Kükenthal 8, p. 93). The Agriodrilus has predating habits.

The families Branchiobdellidæ and Acanthobdellidæ, while phylogenetically not quite as near to the Hirudinea, as the Agriodrilus, since the characteristic arrangement of their reproductive organs, testes posterior to the ovaries as in Agriodrilus and Hirudinea is absent, do show specialization modifications possessed by the Hirudinea. The Branchiobdellidæ are small worms, parasites of sweet water crustacea, whose posterior metameres have fused to form a caudal sucker. The Branchiobdellidæ have lost their bristles. The genital pore is located in the Xth somite, in the clitellar region.

The oligochætes Acanthobdellidæ also relations of the hirudinea parasitize fishes, occur in northern Russia and Siberia, possess a caudal sucker, bristles only on the few anterior metameres and have a greatly reduced boby cavity, which has been filled with connective tissue. There is only one known genus Acanthobdella.

It is important to realize that the bristles of the oligochætes have a median position on the annulations of the worms. The annulations of the Chætopoda carrying bristles correspond to the annulations with the sensory papillæ of the Hirudinea (*Autrum* in Kükenthal 8, p. 253). This is further evidence that the asumption that the sensory ring has a median position as brought forward by *Castle* and *Moore* is correct.

The Hirudo medicinalis Linnæus has a comparatively well developed nervous system. The nervous system of the leech may be subdivided into the central nervous system, the peripheral nervous system and the sympathetic nervous system (*Scriban* and *Autrum* in Kükenthal 8, p. 235). "The central nervous system consists of a series of partially fused ganglia united by twinned nerve cords", cited from *Craig* and *Faust*, page 533. The anatomic unit of the central nervous system of the leech is the so called the normal ganglion, which is also a metameric unit. Each of these normal ganglia has 6 accumulations of ganglionic cells, also designated as follicles. There is a pair of these follicles in the anterior part of the ganglion, the antero-lateral follicles. Between these anterior lateral follicles lies an impair aggregation of ganglionic cells, the median anterior follicle. There is also a pair of follicles situated in the posterior part of the ganglion, the postero-lateral follicles, in between as in the anterior part of the ganglion is the postero-median follicle.

The individual ganglia or swellings of the chain are actually connected by three strands or nerve cords, composed of the neurites of the ganglionic cells of the ganglia of the chain. There are two thicker nerve cords and a very thin nerve cord, the intermediate nerve of Faivre, which on close scrutiny will be found to lie between the thicker nerve cords. The nerve cords are enclosed in neurilemma (*Scriban* and *Autrum* in Kükenthal 8, p. 236).

Lateral nerves emerge from each ganglion. These are composed of the

efferent neurites (motor) of the ganglionic cells contained in the follicles of the ganglia and of the afferent neurites (sensitive and sensory) arising from the very numerous bipolar cells situated in the dermal tissue of the animal.

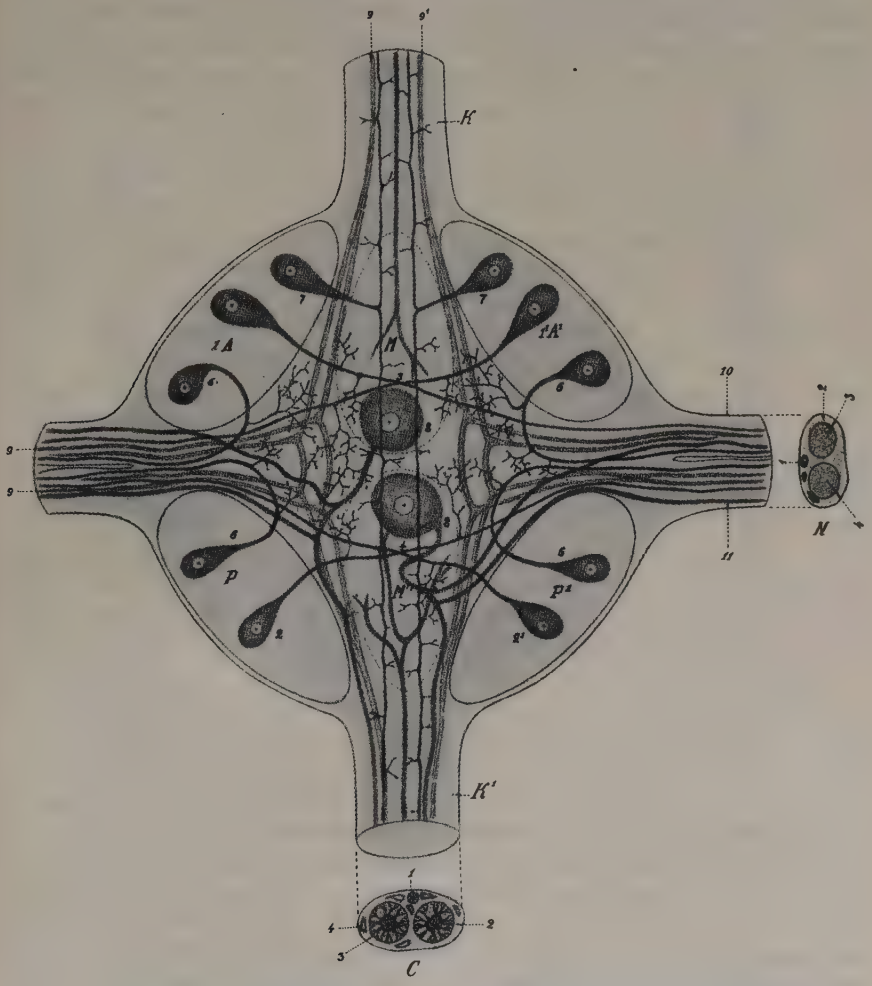
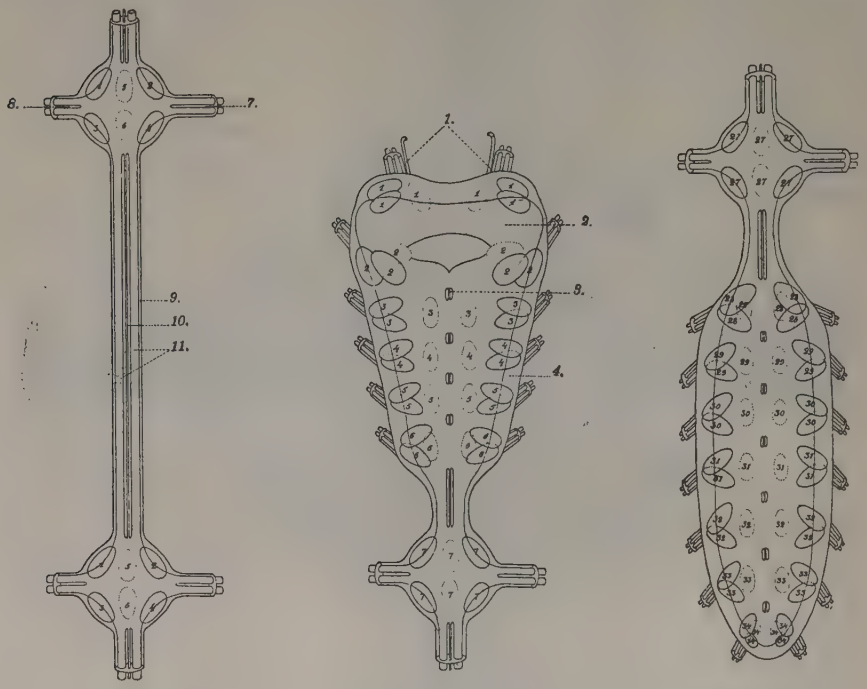


Fig. 2. Scheme of a normal ganglion with the most important cells and fibers.

A number of the neurites of the lateral nerves has its origin in the contralateral aggregations of ganglionic cells or follicles of the ganglion, while the other originates from the ipsilateral follicles.

The central nervous system of the leech consists of a chain of these normal ganglia, each with its six aggregations of ganglionic cells or follicles.

The cerebral ganglion, situated in VIth somite, is the anteriormost and is formed of two symmetrical masses of neural matter, united by a dorsal commissure. Each half of the cerebral ganglion consists of three follicles, composed as elsewhere in the central nervous system of the leech of a conglomeration of ganglionic cells, of tissue called by *Leydig* "Punktsubstanz", which in reality is nothing but the mass of neurites emerging from and going to the ganglionic cells of the follicles, and of a very few glia cells (*Scriban*



Two normal ganglia united by twinned cords. Cephalic ganglion and anterior ganglionic mass. Anal ganglion.

Fig. 3. Illustrations taken from "Handbuch der Zoologie" of Krumbach.

and *Autrum* in Kükenthal 8, p. 242). The cerebral ganglion is united by means of two ventral commissures with the anterior ganglionic mass, which is triangular in form and is composed of 5 fused normal ganglia, each consisting of 6 follicles of the neurites and the few glia cells. The anterior ganglionic mass contains therefore 30 follicles, arranged in two lateral rows of 10 and two paramedian rows of 5. The anterior ganglionic mass has 8 small perforations in its middle. There appear to be only 4 perforations on superficial observation, but on closer scrutiny it will be noticed that each of them is divided by a small median strand of nervous tissue, which corresponds to the nerve of Faivre in the chain.

The anterior ganglionic mass connects with the first ganglion of the chain by means of the mentioned nerve cords.

There is one normal ganglion for each somite. The cerebral ganglion is the ganglion of the first somite, the next 5 normal ganglia of somites II, III, IV, V and VI are fused to form the anterior ganglionic mass as described above, the following 21 normal ganglia of somites VII to XXVII inclusive form the chain, the last 7 normal ganglia of somites XXVIII to XXXIV are again fused into the so-called anal ganglion. In the anal ganglion are also cell groups of ganglionic cells or follicles, arranged as in the anterior ganglionic mass in two rows, situated laterally and consisting of 14 of these follicles. There is also a neurofibrillary, interfollicular substance, a few glia cells, median perforations and an emergence of lateral nerves as in the large ganglion or node situated in the anterior part of the leeches body, the anterior ganglionic mass.

The lenght of the nerve cords connecting the ganglia or nodes is greatest in the middle of the chain. The nerve cords become successively shorter in the anterior and posterior metameres, being shortest in the connections with the anterior ganglionic mass and the anal ganglion.

The follicles of the ganglia are as has been mentioned previously, cell groups of ganglionic cells. These ganglionic cells are pyriform in shape, their apeces are pointed to the exterior of the ganglion, while their neurites extend to and pass through the vicinity of the center of the ganglion. Each ganglionic cell has a nucleus with a nucleolus, a peripheral and a perinuclear rete of neurofibrillæ. All the ganglionic cells of the central nervous system of hirudinea are unipolar, they may be however differentiated into a number of types.

a) ganglionic cells, whose neurites pass through the vicinity of the center of the ganglion or node, enter the lateral nerve and give off, on their way through the interfollicular or "Punktsubstanz" of *Leydig* a dendrite, which branches out in this substance.

b) cells, with a T form ramification of their neurites, whose neurofibrillæ extend to adjacent ganglia through the nerve cords and which give off on their way small dendrites to the neurofibrillary substance, either entering lateral nerves or ending in this substance with further dendrites.

c) giant ganglionic cells, of which there is one in every median follicle of the ganglion. Since there are two median follicles, the anterior and the posterior median follicle in every metameric ganglion, there are two of these giant ganglionic cells in each of them.

The fibers of the lateral nerves, composed of neurofibrillæ, are either efferent or afferent. The motor impulses are carried along the efferent fibers to the musculature, the sensory and sensitive impulses by means of the afferent fibers. The sensitive and sensory impulses originate from bipolar cells, dessiminated through the derma of the animal, from the sensory

papillæ, from the sensillæ of Haekel and from the eyes. Each lateral nerve, shortly after it's emergence from the ganglia of the chain divides into an anterior and into a posterior lateral nerve. The anterior lateral nerves pursue a ventral, the posterior lateral, a dorsal direction (*Scriban* and *Autrum*, in Kükenthal 8, p. 243). According to *Autrum* (in Kükenthal 8, p. 310) the longitudinal musculature is innervated by the posterior, the ring and the dorso-ventral musculature by the anterior segmental nerve. *Autrum* also assumes that the anterior nerve may contain inhibitory fibers for the longitudinal musculature. The anterior lateral nerve, also according to *Autrum* (in Kükenthal 8, p. 306) contains fibers that carry impulses, which accelerate the contractions of the lateral blood vessels. The posterior lateral nerve on the other hand carries nerve fibers, which conduct impulses tending to retard the contractions of the lateral blood vessels (*Autrum* in Kükenthal 8, p. 306). The locomotion of the leech, which occurs by means of an alternate attachment and release of its anterior and posterior suckers to the surface over which it is advancing along with an elevation of the dorsum into the form of an arch and a contraction of its musculature, is under the control of the anterior ganglionic mass. After its extirpation the leech does not undertake any searching actions with the anterior extremity or any locomotion. The anteriormost ganglion, the cerebral ganglion, has an inhibitory action. The removal of the same produces constant unrest and an increased irritability ensues. The removal of only one side of the cerebral ganglion has as a result a contraction of the musculature on the intact side, this side assuming a concave form. A rotation of the anterior extremity also occurs, with the leech turning the side with the removed half of the cerebral ganglion uppermost and swimming, in the sense of the side with undamaged half, in circles. The anal ganglion is necessary to ensure coordinated musculatory action for swimming purposes. The animal can swim after an excision of the anal ganglion only if the cerebral ganglion has also been removed. The conclusion followed is that the cerebral ganglion exerts a strong inhibitory action and that the chain alone can sustain motor innervation of the musculature used in swimming (*Autrum* in Kükenthal 8, p. 310).

The arrangement of the sensory papillæ on the dorsum is peculiar in the different species and is used in their taxonomy. Single visual cells may occur in the papillæ, which in such cases have been called sensillæ by Haekel. Organs which contain numerous visual cells and a dark pigment on the inside surface of the cylindriform excavations, with the neurofibrillæ uniting to a nerve along the axis this cylinder are called the eyes of the leech. These visual cells contain large vacuoles containing a clear mass not staining with hematoxyline. These vacuoles are lined with a radiate fringe of protoplasma. The nerve extends through the axis of the cylinder. The axis of the individual eyes is at a different angle to the surface of the leech. This arrangement permits the leech to discerne motion of an object. Light impulses emitted

by the object strike the visual cells of the eyes as the object moves (*Autrum* in Kükenthal 8, p. 254) in succession.

The sensory papillæ consist of accumulations of elongated epithelium cells. These put out individual thin ciliate protoplasmatic hairs through canals in the cuticula. The sensory hairs, it seems, can be actively protruded and pulled back through the cuticula by the leech. The neurofibrillæ of these elongated bipolar cells unite to form a nerve, connecting with the central nervous system. The sensory papillæ are very numerous on the upper lip. They occur in the oral cavity but not on the inside surface of the caudal sucker (*Autrum* in Kükenthal 8, p. 252).

The huridinea also possess a sympathetic nervous system. This system consists of a network of fibers, enmeshing the whole digestive tract and containing multipolar ganglionic cells (*Scriban* and *Autrum* in Kükenthal 8, p. 245). The sympathetic fibers unite to two denser strands, running on both sides of the œsophagus, the lateral sympathetic strands. In the vicinity of the ring of the central nervous system, formed by the commissures of the cerebral ganglion with the anterior ganglionic mass, and which encircles the beginning of the digestive tube, lie a number of cell nests of these multipolar sympathetic ganglionic cells. Multipolar ganglionic cells are however found throughout the whole rete of sympathetic fibers. There are connecting fibers between the ring of the central nervous system and the sympathetic rete (*Scriban* and *Autrum* in Kükenthal 8, p. 249).

It must be mentioned here that the Hirudo medicinalis Linnæus shows a deviation from the schema of organization of the central nervous system of hirudinea in that the cerebral ganglion is composed of 2 fused metameric ganglia, while the anterior ganglionic mass consists of 4 fused metameric ganglia (*Scriban* and *Autrum* in Kükenthal 8, p. 250).

The leech has also numerous simple perceptory organs scattered throughout the derma of the animal, they consist of ramifications of neurofibrillæ, whose endings end in the subcuticula. The cells are bipolar ganglionic cells, located subepidermally, with an elongated cell body and a slightly ovoid cell nucleus. It is assumed that these numerous cells serve to perceive tactile sensations.

The oligochætes, the ancestors of the hirudinea, have a well developed primary circulating system. This consists of a pulsating dorsal blood vessel (*Michaelsen* in Kükenthal 8, p. 36), connecting by a number of branches with a ventral vessel. There is also an intestinal plexus, placed between the epithelium and the musculature of the intestine. According to *Beddard* this plexus was originally composed of numerous thin-walled vessels, which undergoing involution formed a single cavity. The intestinal plexus communicates with the dorsal and ventral vessels by means of a number of branches. The blood of the animal enters the dorsal vessel from the intestinal plexus; in the dorsal vessel it is propulsed forwards by contractions

of this vessel into 6 pairs of commissural vessels, connecting the dorsal and a subintestinal vessel by means of six arches situated in the anterior end of the worm. From the subintestinal vessel the blood flows into the ventral vessel from where it returns to the intestinal plexus. This primitive circulatory system undergoes a number of changes in the process of phylogenetic development. In some oligochætes we find the body cavity or cœlom becoming partially filled with connective tissue. This connective tissue leaves spaces or lacunæ between its fibers. These lacunæ becoming filled with

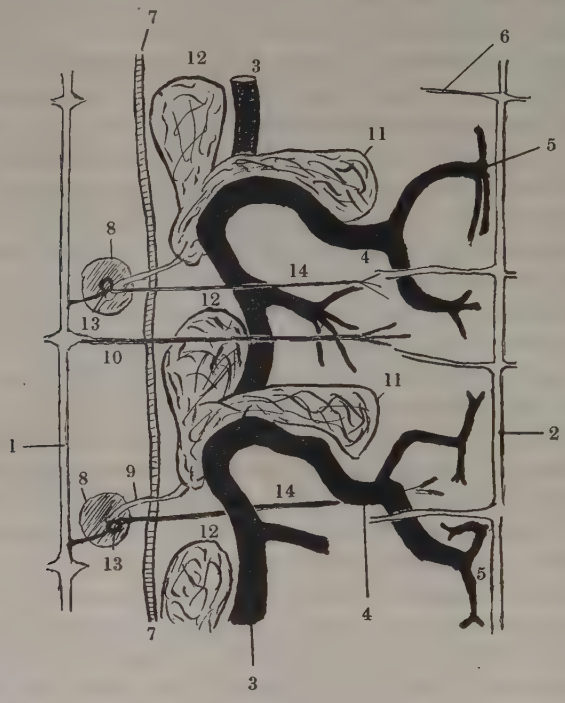


Fig. 4.

1. median ventral blood vessel. 2. median dorsal blood vessel. 3. lateral blood vessel. 4. laterodorsal branches. 5. ramifications of the laterodorsal branches to the botryoidal rete. 6. branches to dermal rete. 7. deferent duct. 8. testes. 9. nephridium, it's free end to testicle. 10. branches to botryoidal rete. 11. glandular part of nephridium. 12. vesicle of nephridium. 13. ampulla with connection to median ventral blood vessel. 14. branch to botryoidal rete. – (Modified from fig. 236 article on Hirudinea by *Scriban* and *Autrum* in "Handbuch der Zoologie" of Kükenthal.)

lymphe, which later in the process of phylogenetic development acquires dissolved hemoglobin, are the beginning of a circulatory system, which assumes ever greater importance on the ladder of phylogenetic ascension.

The more primitive of the hirudinea the sub-order Acanthobdellæ, of

which the family of Glossiphonia are a part, have remnants of the primitive circulatory system found in a well developed form in the oligochæta. The primitive circulatory system of the Glossiphonia consists of a dorsal contractile vessel and of a thin-walled ventral vessel. These two vessels communicate in both ends of the animal by means of a rete. There are no side branches composed of vessels of this primitive circulatory system in the Glossiphonia. On the other hand the secondary system of the Glossiphonia is well developed. This is a system of lacunæ interposed in the connective tissue, filling the body cavity of the animal. Hemoglobin is contained in dissolved form in the fluid or blood filling these lacunæ.

The Hirudo medicinalis Linnæus has no trace of the primitive circulatory system, still possessed in rudimentary form by the Glossiphonia. The circulatory system of the Hirudo medicinalis is composed exclusively of a well developed system of lacunæ or sinuses, located among the mass of connective tissue, which has completely filled the body cavity (*Scriban* and *Autrum* in Kükenthal 8, p. 219). Some of these lacunæ retain their original thin walls, while some develope musculature in the walls of their vessels and acquire the propety of active contraction. Valves also appear in some of the vessels.

The circulatory system of Hirudo medicinalis Linnæus is composed of:

a) *Median ventral blood vessel*, the median ventral blood vessel contains in itself the whole central nervous system of the animal. According to *Craig* and *Faust*, Clinical Parasitology p. 533, the median ventral blood vessel is the ventral trunk sinus, which represents a greatly reduced body cavity. The anterior enlargement of this median ventral trunk contains the ring of the central nervous system, which is composed of the cerebral ganglion and of the anterior ganglionic mass, also called the sub-œsophageal ganglion. A series of enlargements correspond to the series of ganglia of the chain of the central nervous system. The following branches are given off:

(1) *abdominodorsal branches*, pursuing a direction towards the dorsum of the leech, passing between the pouches of the stomach or crop of the animal. They emerge symmetrically in pairs and end in the dermal rete.

(2) *branches to the ampullœ*, these ampullæ are perinephrostomal cœlomatic lacunæ (*Scriban* and *Autrum* in Kükenthal 8, p. 218), they number 10 or 11 pairs (11 pairs if the leech happens to have 10 testes, which frequently occurs (*Autrum* in Kükenthal 8, p. 259), possess layers of muscular fibers enabling these ampullæ to perform rhythmical contractions. The ampullæ are situated in the immediate vicinity of the testes.

b) *2 lateral blood vessels*, these are the largest blood vessels of the leech. They possess two well developed layers of circular muscle fibers, perform approximatively 6 pulsations per minute (*Autrum* in Kükenthal 8, p. 305), whereby the lateral blood vessel of one side is contracted, while the lateral blood vessel of the same segment of the other side is relaxed, the blood

being forced into the branches of the contracted lateral blood vessel. The lateral blood vessels also possess valves, situated in each segment. The valve opens when the contraction wave reaches the next anterior segment. Some blood enters the next anterior segment, but the main direction of the blood flow is transverse.

Branches go off on the median or interior, and on the lateral or exterior side of both lateral blood vessels. The lateral blood vessels communicate with each other in the anterior and posterior ends of the leech by means of a capillary rete.

Branches given off by the lateral blood vessels on the median or interior side are:

(1) *lateroventral* branches, these number 18 pairs, each pair forming an anastomosis, passing underneath the median ventral blood vessel.

Branches given off by the lateral blood vessels on the lateral or exterior side:

(2) *Laterodorsal* branches, these are somewhat longer, than the ones to be immediately mentioned, there are 17 pairs of these laterodorsal branches. The laterodorsal branches of the lateral blood vessels subdivide dichotomically and then split into numerous capillaries, connecting with the botryoidal, or intermediate rete. There are connections between the dichotomic rami of one side with those of the other.

(3) *Laterolateral* branches of the lateral blood vessels. These are shorter than the preceeding, alternate in their emergence from the lateral blood vessels with the just mentioned longer laterodorsal branches. They also number 17 pairs and convey blood as do the laterodorsal branches to the botryoidal rete and to the dermal rete.

c) *Median dorsal blood vessel*, or dorsal trunk sinus. The median dorsal blood vessel has connections to the botryoidal and dermal rete.

d) *Botryoidal rete*, a rete contained in the mass of connective tissue, which fills the body cavity of the leech. The walls of this system of small blood vessels, capillaries and mere crevisses in connective tissue possess large cells, peculiar to this tissue and called botryoidal cells. The cytoplasma of these cells has a dark brown pigment.

e) *Dermal rete*, a capillary system recieves connections from the botryoidal rete, from the branches of the laterolateral, laterodorsal and lateroventral branches of the lateral blood vessels. The capillary rete of the derma of the animal performs the respiratory functions.

The depression of the freezing point of the blood plasma of Hirudo medicinalis Linnæus is $-0{\cdot}43^0$ C. (*Autrum* in Kükenthal 8, p. 303). The blood is of a red color by reason of the dissolved hemoglobin it contains. The blood of the medicinal leech also contains amœbocytes, approximatively 15 microns in size, with phagocytic properties (*Scriban* and *Autrum* in Kükenthal 8, p. 220).

There are reasons to believe that the botryoidal cells perform excretory functions in Hirudo medicinalis Linn. The products which cannot be excreted through the nephridia by reason of their high molecular weight, as biliverdin and fatty acids are excreted by means of these botryoidal cells. The botryoidal cells may possibly wander to the surface of the animal, as has been observed in Batrachobdella paludosa (*Carena*).

The digestive system of the medicinal leech may be subdivided into the foregut, the midgut and the endgut. These divisions of the intestinal tract are themselves to be further separated, by reason of their anatomic peculiarities, into pharynx and œsophagus, into stomach and intestine proper, and into the ampulla recti and rectal canal with the small anal opening.

The pharynx,

commenses immediately posterior to the oral opening, located on the bottom of the oral sucker and formed by three folds of epithelium and dermal tissue of the animal in the form of a triradiate star. The pharynx is lined with epithelium, possessing a cuticula just as the epithelium on the animals outer surface. The well developed musculature of the pharynx is composed of an inner layer of longitudinal and an outer layer of circular muscular fibers.

The 3 jaws of the leech are arranged also in the form of a triradiate star, with their edges protruding through the slits formed by the folds of the oral opening. The jaws have a vertical position in the pharynx. They may be regarded as modified folds of musculature of the pharynx. According to *Scriban* and *Autrum* (in Kükenthal 8, p. 169) the jaws of the leech are composed of layers of musculature, identical in the structure of the fibers with that of the musculature of the pharynx. The jaws are lined with the same epithelium, covered with a cuticula, as lines the pharynx. The cuticula of this epithelium thickens and condenses into the single row of fine teeth which arm the edge of each jaw of the leech. The cuticula of the jaws is thin and does not consist of chitin, according to *Scriban* and *Autrum* (in Kükenthal 8, p. 170). The jaws have muscles attached to their bases, these muscles enable the leech to pierce the skin of the prey with saw-like movements of its jaws.

The numerous salivary glands of the leech are located in the whole preclitellar region underneath the derma. The ducts of these unicellular glands unite into strands, these strands of ducts enter the jaws at their bases, pass through the midpart of each jaw and emerge as fine pores, located between the fine teeth of the jaw's edge.

The anteriormost enlargement of the median ventral blood vessel with the therein contained ring of the central nervous system surrounds the pharynx.

The œsophagus

is short and is separated from the pharynx by a sphincter. The walls possess numerous folds. (*Scriban* and *Autrum* in Kükenthal 8, p. 173.)

The stomach

is separated into 9 chambers by interposed sphincters. Each of these chambers has side pouches. The last chamber has the pouches modified to two long diverticula, extending to the posterior extremity of the animal. A single layer of prismatic epithelium, covering the sack of connective tissue, with intermingled muscular fibers among its layers, lines the stomach wall. (*Scriban* and *Autrum* in Kükenthal 8, p. 174.) The stomach ends with a short funnel, possessing a sphincter, which connects it with the intestine.

The intestine

of the medicinal leech is comparatively short, has no diverticula, no musculature, but the epithelium, lining the interior, is ciliated and thicker than that of the stomach. It has numerous small blood vessels which enmesh it. (*Autrum* in Kükenthal 8, p. 298.) According to *Autrum* the greater part of resorption takes place in the intestine. The intestine connects with a thin communication, with the ampulla recti.

The ampulla recti

is lined with a layer of prismatic epithelium with long cilia.

The anus is small and is situated dorsally just above the posterior sucker. The rectal canal is a short thin tube of the digestive tract, connecting the ampulla recti with the dorsally situated anus. (*Scriban* and *Autrum* in Kükenthal 8, p. 124.)

The medicinal leech uses the blood stored in the pouches and diverticula of the stomach sparingly. One may assume that the leech does not enter the hunger period of its metabolism until the depot of blood contained in the stomach is exhausted. This does not occur before 6 months have elapsed. Even after the exhaustion this depot the leech can live up to $1\frac{1}{2}$ years without feeding. (*Autrum* in Kükenthal 8, p. 297.)

The use of leeches at present and indications for their use in therapy.

Henschen calls the liver the king of the organs. The justification for this appelation is evident. The liver has a king-pin position in the metabolism of fats, carbohydrates, proteine, minerals and vitamins. It plays an important part in the regulation of the water balance and of the excretory function of the kidney. Close correlation exists between the condition of this organ and the processes of digestion. The liver exerts an influence on the stomach. In the circulatory system it occupies a central position.

Because of these considerations and because of the importance pathologic conditions of the liver play as an indication for the use of leeches in therapy, it has been thought proper to attempt to give some excerpts of the exposé given by *Henschen* before the forum of surgeons on the subject of the liver.

Of interest is the stress laid by *Henschen* on the occasion of the 56th Congress of surgeons, taking place in Berlin in 1932, on the importance of a certain functional independance of the two halves of the liver as divided by the *Sérégé-Cantlie* line. This line drawn from the entry of the Vena hepatica into the Vena cava inferior to the gall-bladder, indicates an internal division of the arterial, portal, venous and biliary systems of the liver into two functional halves, the right and the left.

This division is formed by the fact that the blood stream coming from the organs of the left side of the body, i.e. from the stomach, the spleen and colon descendens on one hand and the blood stream from the duodenum, the head of the pancreas, the cœcum, the colon ascendens and the colon transversum on the other, do not mix completely in the course of their relatively short passage through the portal vein.

The division of the blood stream into a sinistrotrope gastro-lieno-hepatic and into a dextrotrope entero-hepatic system is the result not only of hydrodynamic causes. The portal vein, its branches and capillaries, draining the different sections of the intestine and organs, are also under the control of autonomic innervation. The trunk and the main branches of the portal vein have muscular sphincters facilitating the regulation of the blood flow, while valves exist at the enteric radices of the portal vein branches. (*Henschen*, p. 835 of Arch. klin. Chir. Vol 167, 1931.) The sphincters at the porta hepatis and in the hepatic veins entering the Vena cava inferior consist of strong layers of circular musculature. The anatomists of centuries past used to call the portal vein the "cor abdominale". Nervous influences may vary the blood flow through the liver by acting upon the intrahepatic vessels and upon the vessels of the splanchnic area. (*Best* and *Taylor*, p. 286.) The spleen may be conceived of as being a bag or cul de sac catching the overflow of blood from the stomach, the intestine and the liver. The liver itself performs the function of acting as a reservoir in relation to the right heart. It is therefore evident that the volume of blood supplied to the liver and the amount of blood released by the liver to the right heart exert an influence of prime importance on circulation.

The validity of the conception of an existence of a sinistrotrope gastro-lieno-hepatic and of a dextrotrope entero-hepatic system is substantiated by numerous clinical and pathologico-anatomical findings. In amœbic dysentery the frequent abscesses often complicating the course of the disease, are found almost invaribly in the right lobe of the liver. The frequency of abscesses in amœbic dysentery located in the right lobe of the liver in relation to the left is given by *Le Dantec* as 84 per hundred, as 91·1 by *Waring*,

as 98 by *Sierra* and as 93 by *Ludlow* (quoted from *Henschen* p. 845 of Vol. 167, Arch. klin. Chir.).

Carcinomata of regions drained by the right portal stream metastasize "dextrotrope", those of the left portal stream "sinistrotrope". (*Henschen* p. 846 same publication as above.) Phlebogenic disease of the liver caused by pathological processes of the cœcum are all dextrotrope. (*Henschen* p. 846 ibid.) In amœbic dysentery according to *Manson-Bahr* the upper part of the right lobe is the most common site in which the abscesses are found. Also according to *Manson-Bahr* the bilaterality of the liver is a well established fact. *Copher* and *Dick* demonstrated in 1928 that there are three distinct and separate currents in the portal vein. The quadrate and the caudate lobes of the liver have a close reciprocal relation to the gall bladder. These lobes communicate with the gall bladder by a number of blood vessels and numerous lymphatics. Secondary disease of duodenal or jejunal origin has its main location in this middle zone of the liver. This is also the case in cholecystitic processes. Of note is the enlargement of the quadrate lobe known as the lobe of *Riedel* in chronic cholecystitis. (*Henschen* p. 528 in Vol. 173 of Arch. klin. Chir., 1932.)

The zonal differentiation of the liver based upon the principle of the subdivision of the portal system in relation to the effected draining of sections of the intestine or of organs in accordance to the topography of its branches, has a meaning in the sense that the zone of the liver primarily undergoing lesion, or in case of tumour the zone into which original metastasis usually occurs, shows a close correlation to the disease of the drained area. On the other hand a certain zone of the liver exerts vice versa an influence on the condition of the corresponding organ or section of the intestine drained in accordance to its own state of parenchyma and the blood and lymphe circulation. The numerous channels of transmission of impulses to and from a certain zone of the liver via interlacing nerve fibers, plexus and ganglia (the cœliac ganglion is the peripheral brain of the liver, according to *Henschen* p. 849 in Vol. 167 of Arch. klin. Chir., 1931), and also the numerous lymphatics, connecting the different zones of the liver with the corresponding organ or section of intestine drained, should be visualized for the comprehension of the existing intimate relationship between a certain zone of the liver and the corresponding organ or section of intestine which is in reciprocal dependancy with it.

Hahn, Donald and *Grier* performed experiments with isotopic phosphorus and confirmed the division of the liver into two halves in accordance with the organs drained by the portal vein. When the radioactive material was injected into the splenic vein an accumulation of the same was seen in the left liver lobe, if on the other hand it was injected into the mesenteric vein it was found in the right liver lobe.

Henschen uses the expression Syntropy to denote correlated disturbances

of two or more organs occuring by reason of a common noxa. Metatropy for abnormal conditions or disturbances, either originating in or directly involving the liver, where the ensuing damage to the liver or its abnormal state necessarily produces pathology and a reaction in organs of the second or third order in the sequence of their involvement. The expression of Holotropy where the liver disease exerts an influence on the whole organism. Organoteletropy for cases where the liver influences one specific organ and Idiopathotropy for systematic conditions of its own cycle. (*Henschen* pp. 491 and 492, Vol. 173 of Arch. klin. Chir., 1932.)

Of prime importance as an indication for leech therapy are crises of swelling of the liver or glaucomo-hepatopathies as called by *Henschen*. However before considering the crises of swelling of the liver it is perhaps expedient to cite a number of metatropies mentioned by *Henschen* in his publication "On the importance of the liver in surgery" and read to the forum of surgeons on the occasion of the 56 th Congress of Surgeons on March 30, 1932 in Berlin. The close interdependance of the liver and the different organs may be shown and also some facts, which perhaps have not recieved all the attention due them, may be brought forward. The chapter on organoteletrope metatropic correlatory pathology of the liver as given by *Henschen* may be found on pp. 578–616 of Vol. 173 of Archiv f. klin. Chir., 1932.

Chronic disease of the liver and chronic cholecystolithiasis is often accompanied by an anacidity of the stomach. On the other hand acute or fresh cholecystitis often produces a superacid gastritis. "Hepatic dyspepses" the "poussées hépatiques" of the French clinicians have a symptomatology of nocturnal crises, migraine, subicterus, an excessive discharge of bile into the intestine and are often found in conjunction with a sensitivity to certain foods as fats and eggs. Steatosis and lipoidosis of the gastric mucosa is often found in poisoning with mushrooms, lead, arsenicals, phosphorus, antimony and mercury, also after the use of chloroform and in cases of acute and subacute yellow liver atrophy. In liver cirrhosis massive deposition of proteine may occur in the capillaries of the stomach wall, this occurrence leading occasionally to an eliminatory gastritis. The paralytic ileus as a sequela to endophlebitis obliterans hepatica produces a sensation of pressure in the epigastrium, giving the symptoms and signs of pseudocholelithiasis as omphalodynia, fever, paralytic ileus, hepatogenic polycythemia, appearance of leucine in urine and an increase of diastase in blood and urine. One of the most important causes of postoperative ileus is a functional insufficiency of the liver (*Henschen* p. 582 ibid.). Acute dilatation of the stomach and cholorrhagia in the sequence of an operation are premonitory signs of a toxic, postnarcotic dyshepatia (*Henschen* p. 580 ibid.). In the first stages of liver damage the condition may pass through a phase of polycholia, with N-retention, decrease of the alkali reserve, with or without acetonuria. The postpneumonic, the peritonitic, the postoperative, the alimentary fermentative (seen

occasionally after eating fruit), the neuroparalytic atonia after injuries to the cranium or to the spinal cord are forms of the hepatogenic dynamic ileus (*Henschen* p. 580 ibid.).

Diarrhea, either intermittent or lasting, may be caused by liver damage as in case of chronic hepatitis, in which case the processes of detoxication, normally taking place in the liver are either slowed down or incomplete. If the cholomucous synergy is disturbed with the secretion of bile diminished or the anticoagulant property of bile upon enteric mucus lessened, the suscebility to colitis is increased. In such diarrhea of hepatic origin the feces assume a more or less liquid consistency, with no appreciable change of their bile content. Anorexia and "bilous migraine" ensue along with albuminuria, hyperbilirubinemia and gastrogenic vertigo (*Henschen* p. 582).

The group of entero-hepatic metatropies comprises the enterogenic cirrhosis, liver damage in ileus and the colonic liver syndrome. According to *Henschen* disease of the gastro-intestinal system frequently leads to serious functional and anatomic pathology of the liver. A goodly number of cirrhoses of the liver have their cause in pathology of the gastro-intestinal system. In case the secretory function of the pancreas in relation to the production of pancreatic juice is insufficient, liver damage is frequent. Depancreatized dogs die because of a centroacinary destruction of their liver cells, even if given insulin. The pancreatic juice apparently exerts an action on the intestine preventing the formation of toxins, which tend to damage the liver. In regard to liver damage in ileus *Henschen* states that extracts of intestinal mucosa are toxic to the liver and to the whole organism. Blood of animals, in whom ileus has been artificially produced, tapped from the portal or mesenteric vein is found to be highly toxic to healthy animals if injected into them. The poisonous substances contained in the portal blood in ileus are phenol derivatives, indole and H-substances of histamin like character. Disease of the colon is frequently the cause of an insufficiency of the liver (*Henschen* p. 583).

In case the source of infection has its origin in the appendix the nonremoval of the same may lead to a serous postappendicitive hepatitis, which in itself may be the cause of a chronic indurative inflammation of the liver. Alcoholics, fat individuals, usually elderly but occasionally youthful, persons with a constitutionally asthenic liver, in case they develope a focal infection in the appendix may also develope either an acute or chronic toxicosis of the liver. Toxins originating from bacteria or from necrotic tissue produce an acute hepatitic or a chronic hepatotic toxicosis of the liver without abscesses. It is of interest to note that the first signs of liver damage consist of a diminished N-excretion in the urine, a slight bilirubinemia, a positive Hay's test, of albuminuria, indicanuria and occasionally glucosuria. The echo of the liver to an appendicitic crisis is usually in the form of a hypothermia preceded by a slight rise in temperature on the 3rd

or 4th day after the begin of the symptoms. The complexion of the patient assumes en earthly color, the eyes are sunken in, the pulse is fast. A subicterus and a big sensitive liver are observed. Nausea, vomitus and hematemesis underline the gravity of the condition of the patient. The pathological findings are centroacinary necroses in the liver with steatosis.

A patient who has a cirrhosis of the liver and who has undergone an operation as an appendectomy, may develope a serious complication a liver crisis. The cirrhotic liver apparently does not possess the capacity of detoxification to a degree possessed by a healthy liver and products resulting from processes of putrefaction, taking place in the intestine and from decomposition of proteine damage it considerably. *Henschen* speaks of an exacerbation crisis of the cirrhotic liver. These exacerbation crises of the liver occur in patients who had the appendectomy in the early stage and in those who had been operated in the interval, provided that their liver is in a cirrhotic condition. The prognosis may be grave. This condition is frequently confused with a dynamic ileus or with peritonitis (*Henschen* p. 558, Vol. 173).

Only a few less known facts in the form of exerpts from the publication of *Henschen* need be mentioned here on the subject of the correlation of the heart and the liver.

The cardiac patient has an increased total amount of blood and an increased amount of blood in circulation (*Henschen* p. 596). Should the splanchnic region release a considerable amount of blood by means of an opening of the sluice control of the portal and hepatic veins, a weak right heart may not be able to pump out a sufficient amount of blood supplied to it by the hepatic veins and the inferior vena cuva. Overflow into the liver ensues. A number of anatomical anomalies exist by no means rare such as the supradiphragmatic entry of the hepatic veins into the vena cava, or the entry of all of the hepatic veins in the form of a common trunk directly into the right auricle. Such anomalies further the ease with which backflow from the right heart into the liver occurs (*Henschen* p. 596 ibid.).

The congestive liver may be differentiated as follows:

a) *Stationary congestive liver.*

This is a compensatory phenomenon of long duration with little change in the condition of the patient.

b) *Peracute congestive liver.*

This is due to an acute decompensation of the right heart. It is a danger signal and is found in pneumonia, pulmonary disease, pleuritis, acute pneumothorax and in toxic infections.

c) *Accordeon liver, "foie à l'accordéon"* of *Hanot.*

Is found in intermittent acute crises of swelling of the chronic congestive liver.

d) *Congestive liver.*

Nonreactive to digitalis or to digitaloids. Is a backflow crisis of the chronic congestive liver and the decompensated heart.

e) "*Asystolie hépatique*" of *Hanot.*

An insufficiency of the heart whose main and only prominent sign is the enlargement of the liver. Predisposed to the "asystolie hépatique" are alcoholics, fat individuals either gouty or not, patients with chronic malaria, with cholelithiasis, patients with conditions of alimentary intoxication and infection, saturnism and gravid patients. No anascra are found in "asystolie hépatique". The "asystolie hépatique" is a combination of predisposing factors some of which were mentioned above and of anatomical peculiarities of the patient. It is not a useful periphenomenon (*Henschen* p. 597 ibid.).

The chronic congestive liver may wear the mask of every known condition of acute abdomen. It may simulate appendicitis, whereby there will be pain on pressure in typical points (pseudoappendicitis). Or may wear the mask of pancreatitis (pseudopancreatitis), or of ileus (pseudoileus). It may also simulate a crisis of gastro-duodenal atonia, a kidney colic, a splenic crisis, peritonitis or cholelithiasis. The reason for such happenings is the fact that every zone of the liver has a section of the gastrointestinal system in reciprocal interdependance with it, or an organ is in such relationship with a particular liver zone. This section or organ will re-echo to a condition of stasis in the liver, occuring in that particular zone. The whole portal system with all subdivisions may react in response to liver pathology or just one of the subdivisions (*Henschen* pp. 528, 529 and 597, 598 of Vol. 173 of Arch. klin. Chir. 1932).

The kidney and the liver have also close reciprocal functional and pathological relationships. Insignificant vascular connections exist between the portal and the caval systems. These are thin branches emerging from the vena mesenterica inferior and proceeding to the capsule of the kidney. They communicate with the external renal arcade. There also exists a communication between the splenic and the left kidney vein by means of small venous branches. In case of liver cirrhosis these thin connections undergo hypertrophy and may attain the thickness of a finger. Of importance is the fact that the blood supply to the renal cortex may be influenced by these hypertrophied connections in liver cirrhosis. The raised pressure in the portal vein leads to an opening of these connections between the portal and caval systems and the resulting stasis in the renal cortex produces the signs of hematuria, albuminuria and pathology of the kidney in form of an epithelial degeneration of the kidney.

Disease of the liver parenchyma can lead to a nephritis hepatica (*Volhard*).

The crises of swelling of the liver may be classified in the following manner.

a) *The acute inflammatory edema of the liver.*

This is a toxic phenomenon often occuring in infectious disease. Diphtheria and scarlatina in their toxic forms, black water fever, pneumonia, typhoid in its early stages often produce a clinical picture called the "syndrome biliare fruste" by the French clinicians. The signs are moderate bilirubinemia, urobilinuria, positive Hay's test, frequently diarrhoid discharges of decolorized and fetid stool, hypothermia, subicteric coloring of the patient with the face assuming an earthy appearance. A papulous rash may appear on the body. The liver is found to be swollen and sensitive on palpation. There is spontaneous pain in the right hypochondrium, radiating to the right shoulder. The patient is nauseated and occasionally vomits. The acute hepatitis is also found as a complication in appendicitis with bad prognosis. According to *Shimazono* edema of the liver occurs in cases of acute beri-beri.

On autopsy an edema permeating and filling the pericapillary spaces of Dissé is found. In case the edema is pronounced, the capillaries may contain little blood and the liver cells may be damaged by the anoxia and the pressure.

b) *Intermediate crises of swelling of the cirrhotic liver.*

Acute hepatitic conditions in a cirrhotic liver can cause the death of the patient through the developing insufficiency and autolysis of the damaged liver parenchyma (*Henschen* p. 859, Vol. 167 of Arch. klin. Chir. 1931).

c) *Swelling of the liver after contusion.*

The swelling of the liver after a contusion may be either diffuse or localised. An important cause of such swellings is the ensueing acidity of the liver parenchyma in analogy to the swelling of brain parenchyma after contusion (*Henschen* p. 860 of Vol. 167 of Arch. klin. Chir. and Zbl. Chir. 1927, No. 50).

d) *Swelling of the liver through infiltration of the Capsula Glissoni with lymphe.*

In early stages of Grave's disease in which an accentuated activity of metabolic and secretory processes exists in the liver, a swelling of the capsule is frequently observed. A diffuse infiltration of the interlobulary connective tissue is often seen in typhoid, paratyphoid, typhus, influenza, small pox and diphtheria is often seen on autopsy [*Rössle*]).

Henschen is of the opinion that frequently a swelling of the liver is caused by the infiltration of the interstitial connective tissue of the liver the Capsula Glissoni, with lymph and mononuclear elements. This probably occurs much more frequently than is seen at autopsy. The infiltration of the capsule could also possibly be the expression of an increased resorption of products of metabolism, some perhaps toxic, released by the liver cells.

e) *The swelling of the liver as a result of sudden release from pressure.*

This phenomenon may be conceived of as being a condition occuring on

sudden decompression of congested bile in the bile ways and ductuli. If a calculus of the choledochus is removed and this removal is followed by a too thorough drainage, which extends to the fine bile ducts, such sudden decompression may be followed by liver edema. Similarly edema of the lungs, the mediastinum and of the heart muscle may be seen in cases where big substernal goiters are suddenly removed from the thoracic cavity. It is common knowledge that brusque cathetrization of an uronephrotic kidney may result in damage to the parenchyma of such a kidney by reason of the ensueing sudden decompression. The resulting edema of the liver may be followed by a complete interruption of its function.

f) *The angioneurotic edema of the liver.*

The crises of swelling of the liver in cases of spasm of arteries of the Tripus Halleri may be differentiated as occurring in individuals with healthy abdominal arteries and such that occur in individuals with arteries occluded to lesser or greater extent by arteriosclerotic changes of the arterial walls. In the first case these spasms have a purely neurogenic basis. Young persons who smoke cigarettes excessively are subject to spasms either of the hepatic artery only or to spasms of all of the 3 branches of the cœliac artery. Patients suffering from hemicrania may have spasms of abdominal arteries in conjunction with their attacks of hemicrania or a spasm of an abdominal artery may develope as an equivalent of an attack of hemicrania. Children suffering from hemicrania have often such attacks of angioneurotic origin as an equivalent in the abdomen (*Henschen* p. 862, Vol. 167 of Arch. klin. Chir.). Persons who have subjected themselves to nicotine poisoning may show a symptomatology resembling that of tabetic gastric crises. Such nicotine poisoning need not necessarily occur in persons not used to the abuse of nicotine, but may be seen in cigarette smokers who are predisposed to angioneurotic crises. A gastric migraine may be accompanied by a spasm of the transverse colon, spasm of the cystic duct with resulting cholestasis, spasm of the sphincter of Oddi with ensueing subicterus. The "migraine abdominale" may produce intense acute pains in the epigastrium, nausea and vomitus, abnormal thirst, diarrhea, a "hard" abdomen, meteorism, symptoms of a spastic ileus, diminishment of secretion of urine by the kidneys and in cases of angioneurotic edema of the liver of allergic etiology a concurrent glottis, lung or skin edema.

Patients who have arteriosclerotic changes of the walls of abdominal arteries may have intermittent attacks resembling the symptomatology of dysbasia intermittens or stenocardial conditions. The conditions of spasm in arteriosclerotic patients have more serious results than spasmic attacks of patients with healthy abdominal vessels. The healthy organism effects a relaxation of the spasm before appreciable damage to the liver parenchyma through anoxia is produced. Such reactive loosening of the spasm may be

impossible in cases where considerable arteriosclerotic changes exist (*Henschen* p. 863 ibid.).

Crises of swelling of the liver may also be the result of stasis of either infected or noninfected bile (*Henschen* pp. 870 to 879 of Vol. 167 of Arch. klin. Chir.).

These examples of glaucoma of the liver of various etiology should make the importance of the condition of this organ in relation to state of the organism an as entiety evident. The glaucoma of the liver (*Henschen* p. 885 of the publication given above) is defined by *Henschen* as an acute or subacute solitary or intermittent condition of swelling of the liver with a pathologic rise of the intrahepatic pressure. The increase of internal pressure in the liver chokes the flow of blood and bile in a zone or in the whole organ. The parenchyma of the liver is further damaged by the edema which follows. For a detailed symptomatology pp. 886 to 892 of the publication by *Henschen* "Die akuten, subakuten und chronischen Schwellungskrisen der Leber" as presented at the 55th Congress of Surgeons should be consulted (Arch. klin. Chir., Vol. 167, 1931).

On page 894 of this publication *Henschen* recommends the application of 12 to 16 leeches in the right hypochondrium. *Henschen* states that most painful states of congestive liver conditions may be promptly relieved. Occasionally according to *Henschen* it may also be advisable to apply leeches to the anal region as a supportive measure. *Henschen* also recommends a number of other measures in a liver crisis as sodium sulfate to effect evacuation of the bowel. *Henschen* does not recommend the use of morphine and camphor as these drugs may cause additional damage to the liver. In regard to surgical treatment of liver glaucoma as decompressive trepanation, hepatostomia superficialis, hepaticostomia profunda and hepato-cholangio-enterostomia as modified by *Kocher* the original publications of *Walzel* and *Kocher* should be consulted.

In toxemias of hepatogenous origin and in conditions of hepatargia a venesection and evacuation of 400 to 800 cm^3 of blood immediately followed by an infusion of normal saline or plasma is given as therapy by *Staub*. *Staub* also states that the application of 12 to 20 leeches in the right hypochondrium is a life saving measure. *Staub* explains the action of the leech application as producing an impulse to effect the stimulation of the pathologically deviated hemodynamic function of the liver. *Staub* and *Henschen* both recommend the diathermy of the liver. *Henschen* recommends to follow the venesection with a blood transfusion.

The experience of the Basle surgical clinic shows that the application of leeches produces good results in phlebitis, cellulitis, acute catarrhal conjunctivitis, acute otitis media and mastoiditis (personal communication by *C. Henschen*). In various affections of the liver leeches applied to the liver region or to the verge of the anus may afford manifest relief according to *Waring*

and *Lukis*. These authors state that leeches should not be applied immediately over a large prominent vein, nor to the eyelids, nor to a bosom of a woman, nor to the loose skin of the penis or scrotum, as bites in these sites may cause inflammation. *Waring* and *Lukis* advise to be careful in the application of leeches in the evening, especially in cases where leeches are applied to young children. If put on in the evening the sites of the leech bites may resume bleeding while the attendants are asleep and the child may succomb to the hemorrhage. *Sulger* and *Bozsin* state that they have found the loss of blood to amount to 500 g in the ensuing afterbleeding in cases where 4 leeches were used. Since all authors who have had considerable experience in the use of leeches recommend to permit the sites of puncture of the skin, produced by the action of the animals jaws, to bleed freely, this bleeding being necessary should the desired relief from pain and tension be afforded to the patient and the possibility of infection and inflammation excluded, the loss of blood may attain considerable quantities. It is evident that a loss of 500 g of blood may have serious consequences in a young child. A simple method of determining the amount of blood evacuated in the afterbleeding is to weigh the dressings. In the application of leeches to the proximity of the anus care must be exercised that the leeches do not creep up the rectum. In case this should happen it is best to visualize the leech at once with a speculum and to place 5 to 10 g of salt on the animal which measure will effect the release of the leech. *Aschner* and *O. Meyer* both recommend to permit the bleeding to continue until it stops of itself. *Sulger* and *Bozsin* have used leeches extensively and have not seen a single case of infection in over 2000 leech treatments. In all cases bleeding from the bites was permitted to take place. Therefore it would seem to be advisable also in case a leech should creep up the rectum, to permit bleeding from the wound in the mucosa to take place, after the leech has been removed by the application of salt onto the animal. It is not advisable to try rip a leech off after it has effected a hold, though it is not too probable yet the possibility exists, that a small piece of the leeches' jaw could remain lodged in the mucosa and set off a chain of events leading to an infection.

The mechanism of the bite of the leech is a complex phenomenon. The effects produced by the bite of the leech are not identical with the action of an intravenous injection of heparin. Heparin is an ester of mucoitin and sulfuric acid containing approximatively 35% sulfur and inhibiting in a dosis of 2 mg 100 cm^3 of human blood for a period of 1 to 60 hours in vitro. Heparin acts on the prothrombin of the blood in the first phase of coagulation and in combination with serum albumin on the second phase (Compendium Roche). *Lenggenhager* investigated the action produced by the bite of the leech and applied leeches to extremities which were to be amputated. He excised the site of the bite and recovered through extraction 1 to 1·5 mg of hirudin from each. *Lenggenhager* also ascertained by means of

autoexperiment that the bite of the leech is practically painless and that the site of the bite showed a markedly reduced sensitivity. This anesthesia is not produced by hirudin. Injections of hirudin into the cutis and subcutis did not produce any anesthesia whatsoever. The 1 to 2 mg of hirudin injected by the leech can not explain the prolonged bleeding which takes place after its bite. The amounts of hirudin injected by the leech would suffize to exert an anti-coagulant action only on 10 to 20 cm^3 of blood, while considerably greater amounts flow out of every wound set by the bite of the leech. According to *Lenggenhager* hirudin is not only an antithrombin but also an antithrombokinase. Hirudin inactivates the thrombokinase released by the damaged cells of the wound and the blood flows from this lesion, whose surfaces have been neutralized in the same manner it does in a blood vessel with an intact endothelium. *Lenggenhager* injected 3 mg intracutaneously and perforated the skin at the spot where the hirudin had been injected, the resultant bleeding continued for a number of hours. The bleeding can be immediately stopped if some gauze drenched with thrombin is applied to the wound, however the gauze must be retained on the spot of the bite for quite some time, because otherwise the fibrin that has been formed is removed with the gauze and the bleeding recommences.

Liebich states that the bite of the leech also inhibits the contraction of the capillaries. The relief afforded to the patient is according to *Liebich* due to the suction exerted by the leech in the process of filling itself with blood and to the prolonged bleeding which follows the bite. A number of investigators have failed to detect any difference in the coagulation time of blood taken at a distance from the site of the bite (*Sulger* and *Bozsin*, *Liebich*) and have concluded that the action of the bite of the leech is a purely local affair. This assumption appears to be erroneous because the leech produces a wound which bleeds for a considerable lenght of time; during this period of bleeding a steady flow of lymph occurs towards the wound produced by the bite. *Magnus* has observed that the capillaries in the proximity of the leech bite loose the faculty of contraction in response to stimuli as do the capillaries not in the immediate vicinity. According to *Lindemann* the leech also injects substances possessing properties similar to those possessed by histamin. Since it is a well known fact that the condition of the peripheral circulation, as for example local hyperemia, produces a reflectory action on visceral organs, the effect of an augmented flow of lymph to the wound set by the leech can not remain without effects upon parts of the body not in the immediate proximity of the bite. The good effects of the application of leeches in crises of swelling of the liver and in migraine can not be explained by purely local action.

Oberheid gives the case history of a 53 year old female patient with a persistent cephalalgia and a blood pressure not falling below 205 systolic and 140 diastolic, in which case *Karell* diet, rest in bed, phlebotomy with

withdrawal of 280 cm^3 of blood afforded no relief. The application of 4 leeches in the nape of the neck resulted in diminished headache and a drop of the blood pressure to 185/100. However the blood pressure went up to 205/115 in a few days after the patient was out of bed; the headache was not complained of by the patient. Thereupon another 4 leeches were used with the result that the cephalalgia did not recur and the patient could be sent home with a blood pressure of 175/100. *Oberheid* treated 17 cases of sciatica with leeches, of these 6 were cured, 8 showed a marked improvement and 3 showed no change in their condition. She also treated 14 of cases trigeminus neuralgia with leech application. However in these cases the results were not definitive. Only one patient showed no recurrence of symptoms, 2 patients showed a marked improvement for a considerable length of time, while the others had a recurrence of their symptoms within 2 weeks. *O. Meyer* has called the attention to the fact that a latent phlebitis of the jugular veins is often overlooked. This phlebitis of the jugulars often acts as a site of a focal infection and good results are often obtained by the application of 3 leeches in the proximity of the jugular vein if this vein is found to be sensitive to light pressure. *Meyer* believes that through the leech therapy the intima of the vein regains its normality by reason of the curative action of the bite of the leech on the endophlebitic processes taking place in the vein. According to *Meyer* the endophlebitis of the jugulars is often the result of a tonsillitis. Tertiary foci of latent phlebitis are often found in the veins of the legs in such cases. Tooth and tonsil infections must be treated before the leech application can be expected to give satisfactory results. *Meyer* has obtained good results in the treatment of brachial neuralgia with leech application immediately over the clavicle with the object of treating an existing endophlebitis of the subclavia. *Meyer* states that the diminishment of the swelling of the intima of these veins produces a more effective draining of the blood from the sinus of the cranium, this often giving the patient definite relief in neuralgia of the Vth cranial nerve.

It is perhaps expedient to underline the fact that the bite of the leech produces a small triradiate scar, which is a permanent mark of its bite, surrounded by a circular area of hyperpigmentation which, while not very prominent may not be appreciated by a number of patients. The patient must be informed of this before leeches are applied in every case of their use.

Meyer lets the site of the bite of the leech bleed for approximatively 8 hours. He has treated on the average 3 patients daily in New York City with leech therapy for over a decade.

Bernard Aschner, one of the modern pioneers in leech therapy, uses leeches applied to the lower abdominal region for the treatment of metritis and perimetritis and also in cases of painful tumors of the adnexes. *Aschner* uses 5 to 10 leeches, the patients obtain prompt relief from pain in the great majority of cases. Pyosalpingitis, parametritis and pelvioperitonitis react

well to leech treatment according to *Aschner*. Leeches are also indicated in cases where the menses are weak and in cases of constitutional amenorrhœa.

Tibbles recommends the use of leeches in glaucoma. He gives the case history of a 50 year old patient afflicted with glaucoma. He applied a couple of leeches to the left, previously well cleaned, temple of the patient. The tension became normal. Eserine however was also used. *Tibbles* put the leech into a tube to effect a bite at the desired location and since leeches are naturally repulsive to most patients he also placed a sheet of paper between the leech and the patient's eye.

Bruck says that good results are obtained through the use of leeches in children in cases of otitis media and in mastoiditis. The leeches according to *Bruck* should be placed behind the child's ear and not in the face or at the temples. Also the leeches are not to be used directly over a vein. Leech bites in the face and at the temples produce infection more easily. Thorough bleeding after an application is important. If the bites are not allowed to bleed out sufficiently they become inflamed after a few days. *Bruck* saw good results obtained with leeches in epididymitis and orchitis. In apoplexy leeches should be applied to the nape of the neck, this is also said by *Bing*. In cases of parametritis *Bruck* says that the results of treatment with leeches are better than those obtained with heat and tamponade. Very good results were obtained with leeches in the treatment of ectases of veins of the legs if such treatment was followed by an application of a zinc-gelatine bandage. However one should take care and not use leeches in the early stages of thrombosis. In the case of thrombosis *Bruck* has made it a principle not to apply leeches before 6 days had elapsed after the commencement of the symptoms or signs showing that the patient was in the process of developing or already had developed a thrombosis. *Bruck* states that after he conscientiously adhered to this practice he had no cases of embolism.

Schreiner used leeches with success in the treatment of epididymitis. According to *Schreiner*, *Henschen* was the first to reintroduce the use of leeches in therapy.

Heisler reports the case history of a cobbler whom he treated for cellulitis of the hand. The infection had started at the basal phalanx of a finger and had developed into a nasty condition. *Heisler* put the question to himself, as to what extent would the ability of the cobbler to earn a living for himself be impaired, in case his hand did not regain full function after a sufficiently large incision into the palm of the hand. Considering the probability that in any case the resultant scar would impair the use of the hand by the cobbler, *Heisler* developed doubts as to the advisibility of a deep incision into the vola manus in this particular case. *Heisler* first treated the hand by immobilisation on a splint, then had the hand bathed 3 times daily in hot soapy water and later applied balsam of Peru and also methyl violet. *Heisler* also states that he tried compresses with camphor wine. None of

these measures had any appreciable effect. The cellulitis of the hand did not improve. The hand of the patient remained swollen, painful and hard. *Heisler* likens the degree of hardness to that of a board. As a last resource before proceeding with the incision *Heisler* applied 5 leeches. Two days after the leeches had been put on a considerable amount of thin pus was discharged and a short time thereafter the hand was fully useful. *Heisler* further writes, that the same cobbler returned a month later with a cellulitis of the other hand. There again was a small laceration at the basis of a finger and cellulitis had developed as sequence. Also in this case the use of leeches restored the hand promptly to normality. The result in both cases quo ad functionem was perfect. *Heisler* also saw good results when he used leeches in cases of thrombosis and phlebitis. In a case of thrombosis of the jugular veins with high fever *Heisler* applied leeches to both jugularies and had good results.

Mahorner and *Ochsner* treated a number of cases of phlebitis with leeches and observed a rapid disappearance of pain, subsistence of the fever and of the edema and a disappearance of the tenderness. They recommend the leech treatment as the best available method of treating phlebitis.

Klapp states that the evacuation of blood produced by the bite of the leech with the ensuing diminishment of stasis and congestion of blood, is in the present day the best available treatment for such congestionary conditions which follow thrombosis.

Volhard recommends the use of leeches in anuria. The leeches are to be placed in the lumbar region.

Leeches have been used often with success in the treatment of pericarditis, pleuritis, endocarditis and a number of other diseases and ailments. *Meyer* has recommended to use leeches in the treatment of poliomyelitis and states that in cases of acute meningitis following measles he has seen dramatic results. *Meyer* is of the opinion that the inflammation of the jugularies has a definite relationship to poliomyelitis. The leech treatment according to *Meyer* removes the inflammatory phlebostenosis of the jugulars thus easing the flow of blood through the jugular veins and decreasing the tension of the liquor cerebrospinalis with resulting improvement in the patients condition.

To summarize it may be said that the use of leeches is indicated in all conditions where blood and lymph stasis exists. The leech treatment also exerts an influence on the intima of veins improving the flow of blood through them. The leech treatment also has a reflectory action on organs at a distance from the site of their application. The use of leeches, if judiciously used, will give relief to the patient in a variety of diseases and ailments, diminish inflammation, stasis, congestion of blood and lymph and shorten the period of recovery from disease.

Henschen had originally also recommended the use of leeches as a pro-

phylactic measure to reduce the occurrence of postoperative thrombosis and embolism in 1928. The question of the causes of postoperative thrombosis and embolism is quite beyond the scope of this paper and my competence, however it may be pointed out that it is a well known fact that the causes of thrombosis and embolism are manifold and varied. Thromboses of the veins of the legs are a frequent occurence. *Rössle* examined 324 corpses and found thrombosis in the veins of the legs in 88 cases. To exclude a possible confusion with postmortal coagulation of blood *Rössle* examined the veins in 53 cases microscopically, whereby the affected vessels were imbeded and series cut. Thromboses of the veins were found in the bodies of persons who had died through accident, suicide and murder. According to *Rössle* ¼ of persons seriously sick have thromboses in the veins of their legs. Thrombosis occurs more frequently in persons who are predisposed to such, by reason of a variety of causes, as sluggish circulation in the extremities, anatomic changes of the intima of the vessels, obesity, changes in the albumin globulin ratio, in the viscosity of the blood and metereologic conditions, to name a few. *Sulger* and *Bozsin* applied leeches as a prophylactic measure for a period of one year to all patients undergoing operation and came out with a total of 19 cases of fatal embolism in somewhat over 33 hundred operative cases. In the preceeding year the occurance of fatal embolism was 18 in approximately in same number of operative cases. While *Sulger* and *Bozsin* fail to see any benefit from the prophylactic use of leeches in relation to a diminishment of fatal embolism from their series, there appears to be no reason to assume that the leech treatment produces an increase in the number of fatal embolies. The difference of one case is so small that it can not be interpreted to signify an increase in incidence. The numerous other reasons that are liable to cause a fatal embolism most certainly overweigh in importance the effect of the few leech bites *Sulger* and *Bozsin* used.

The thrombosis of phlebitic and periphlebitic origin must be differentiated from the aseptic non-inflammatory type. While the thrombus of phlebitic and periphlebitic origin developes gradually, is accompanied by pain, edema and possesses a regular structure of its fibrin fibers, containing the various corpuscular blood elements, the non-inflammatory aseptic thrombus can develope with great rapidity and without any pain whatsoever. The edema may be missing. The structure of the aseptic non-inflammatory thrombus is irregular and disorderly. Considerable portions of the thrombus may be insufficiently attached to the wall of the blood vessel in case the thrombus developed with great speed and the reaction of the intima of the vessel was negligible. It is evident that the last mentioned type of thrombus is the one most frequently causing embolism.

Leeches have been used in the treatment of certain postoperative and spontaneous thromboses at the Surgical Clinic of the University with good results. The best results were obtained in thromboses of the inflammatory

type. They have also been used in Basel with success as a preoperative measure to reduce the incidence of thrombosis in patients having phlebitis. When they are used as a measure to reduce the incidence of thrombosis it must not be forgotten that there may be an increased tendency to hemorrhage, this especially in prostatectomy and in other operations taking place in the small pelvis (*C. Henschen*, personnal communication for the above).

In patients with manifest thrombosis, who are being treated with heparin they may be used as a supportive measure by reason of the antispastic action of their bite on the musculature of the blood vessels. Venous or arterial spasm may be diminished or suppressed and the cirulation through the spastically contracted vessel reestablished by means of the application of leeches. In phlebitic processes an antiseptic effect is often seen. This may be explained to be the result of the better blood supply of the affected vessel due to the release of an existing spasm of the blood vessel musculature, whereby the intima, media and adventitia receive more nourishment from either the lumen of the vessel or the vasa vasorum. The better blood supply reduces necrosis, this in turn results in less suitable medium favourable to bacterial growth.

Runge saw good results from the use of leeches in obstetrical practice and had used them extensively in Greifswald in 1932. *Wimhöfer* reports on 70 cases of either gynecologic postoperative or postpartal cases of thrombosis that were treated with leeches. *Wimhöfer* states that 2 to 6 leeches were used in each case. In most cases 3 to 4 leeches were applied to the median surface of the thigh and one to 2 on the calf of the patient. After the bleeding had subsisted the whole lower extremity was bandaged with an elastoplast bandage. Splints were not used. In all cases pain ceased promptly, the edematous swelling was diminished, temperature and pulse rate dropped. *Wimhöfer* explains the results obtained through the decongestive and vasodilatory action of the leech bites. According to *Wimhöfer* adipous patients, cases which were operated for myoma, carcinoma, and who underwent a total vaginal extirpation are predisposed to thrombosis. In a total of 434 operative cases the incidence of thrombosis was 8, the incidence of embolism with infarction was 4, of which 2 were fatal. As mentioned previously the incidence of thrombosis and of embolism undoubtedly depends to a great extent on the type of operation performed and the general condition of the patient. Considering the fact that fatal embolism is comparatively rare the opportunity afforded to study its frequency in relation to certain specific conditions is limited. In case the general condition of the patient is unsatisfactory, a relatively small infarction may suffize to set off a sequence of events, which in the case of the presence of other pathology can cause the death of the patient. A limited number of such cases can greatly influence the appearance of a table or of a curve and the sum total of a statistical compilation. It is well known that statistics may be very

misleading. Very often deductions followed, from a sum of figures which have been compiled without the consideration of the age, the general condition, in the case of postoperative cases of the experience of the operating surgeon or the technique employed, the type of narcosis used, may be quite misleading. Some of these factors influence a set of figures more than the mathematically possible deviation from the possible mean average as computed through formulas. *Wimhöfer* states, that while the incidence of embolism in cases treated with leeches was not less than the frequency of such an occurrence in the general average, there is no reason to assume from the figures available, that there is an increase of the frequency in the occurrence of fatal embolism after the use of leeches. However as mentioned previously, the available figures are so small, that a sudden death of a patient, who has had a number of attacks of minute or insignificant infarctations, some perhaps not even noticed by the nurse or the attending physician, may easily tip the scales of such a set of figures.

In conclusion it is necessary to say a few words on the technique employed in the application of leeches, the manner in which these animals may be kept, the question of possible transmission of disease through leeches, and on the practice of killing leeches after they had been used for therapeutic purposes.

According to *Moquin-Tandon* it is important to use healthy starved animals. A great number of measures have been recommended which are supposed to effect a better chance that the leech will bite at the desired spot. Covering the skin at the spot where one wants the leech to bite on with milk or sugar water has been recommended. According to *Menemachus* and *Leuze* the skin of the patient where one expects the leech to bite must be clean and free from grease. *Leuze* gives the directions of thoroughly washing the skin of the patient previous to the leech application with hot soap and water. One puts on leeches in the early morning. Just before their application the skin is washed with hot water only. The patient must be in bed in a relaxed position. The area surrounding the site of application is covered off with sterile gauze or napkins. The leeches may be applied by means of a glass tube 10 mm in diameter open at both ends, or by placing the leech into some gauze and keeping this gauze loosely for some time at the location selected for treatment. This last procedure is to be recommended in case the technique of inducing the leech to crawl into the tube is found to be difficult. *Leuze* says that if one pours off the water from the container or jar into which the leeches were placed the animals commence to crawl up the sides of the vessel and one holds the small glass tube in the path of the leech. *Leuze* says that it is not easy to get the animal to crawl into the tube until one has acquired sufficient experience with the technique, but this is soon learned. When the jaws of the leech pierce the skin the patient experiences a prickling sensation. After the leech has bitten on, the tube is

gently withdrawn. It is not possible to force the animal into the tube. Any damage to the leech will prevent it from biting. In no case is the process of leech application to be turned over to attendants or nurses. A possibility of an inflammation at the site of the bite may occur and the physician will be held responsible for any disagreable after-effect which may possibly occur. Also since the use of leeches is commonly indicated in persons predisposed to thrombosis and embolism the physician should be present to be able to take immediate action in case of embolism, as the administration of eupaverine. The patient must remain in bed during the whole period of bleeding from the leech bites, which are covered with a sterile dressing after they have dropped off. The dressings should be changed when they are soaked with blood and the evacuated cell secretion and blood should be weighed in order that the loss of blood may be determined. The patient should be attended by the nurse during the whole time the bleeding from the bites is taking place. To obtain the full benefit from the treatment the patient should be comfortable, relaxed and in quiet surroundings. In case the bleeding does not stop after 10 or 12 hours a thrombin preparation should be placed on the bites and the dressing left in place for a few days. According to *Leuze* occasionally it is necessary to use silver nitrate caustic to stop the bleeding.

For a short period the leeches may be kept in an absolutely clean jar which have been thoroughly scrubbed with hot water and a brush. *Leuze* states that no soap may be used to clean the jar.The jar should be of earthenware and preferably one that has never been used. The animals are very sensitive to alkali, changes to the p_H and to alkaloids. They are especially sensitive to nicotine. Cigarette smoke is sufficient to prevent them from biting. The water in the jar must be changed daily and in summer time it may be necessary to change it even more frequently.

It is wrong to keep leeches in artificial surroundings as in a jar for more than a couple of days. The best way to keep leeches is in a small pool 6 inches deep at the greatest depth with a slanting uneven bottom. The bottom should consist of clay or sand and emerge to small mud flats from the water. The leech is not an exclusively aquatic animal. For complete well being it must be able to emerge from the water occasionally. The leeches emerge from the water to mate and to deposit their eggs contained in cocons. Aquatic plants as Acorus calamus, Nymphea and others should be planted in the pool or tank (*Moquin-Tandon* p. 233). The pool should not be exposed to too much sunlight nor should it be kept in darkness. It is best to have the bottom gently slope upward on one side as mentioned previously. The level of the water should not change, but it should have a facility of gently replacing itself. The pool or tank should be large enough to provide a sufficient detoxication of the water.

In Basel the leeches were kept in practically ideal conditions. The tank

had a 6 inch deep layer of soil, clay and mud as bottom which sloped gently upwards on one side and which was covered with a not too thick growth of aquatic plants, these affording to the leeches places of refuge under which they could seek shelter. It can be stated that the leeches were in surroundings which corresponded very closely to their natural habitation.

If one has two tanks of this type one can throw the leeches that have been used into one of them. One may also have a number of smaller tanks in which leeches may be starved before their use.

It should be remembered that one has less trouble to get the leeches to bite if they are healthy vigorous animals. The greatest amount of failures experienced in the use of leeches is due to the attempt to use sluggish, sickly animals. It is an unpleasant to have to interrupt the application of leeches to a patient because one can not get the animals to bite.

In regard to the transmission of disease through leeches, the experiments of *Mühling* are worthy of note. *Mühling* let leeches suck themselves full with blood of mice and organs which had been infected with Anthrax. The fact that the leech had actually sucked the infected blood was ascertained by *Mühling* through observing the appearance of the characteristic triradiate wound on the skin of the mouse or on surface of the spleens taken from infected mice and the increase of the volume of the leech. *Mühling* found that the Anthrax bacilli died very soon in the leech. *Mühling* took the blood which was contained in leeches that had sucked blood from infected mice 3, 6, 11 and 13 days after feeding and injected the blood into white mice. In no case was there an infection of the injected mice with Anthrax. *Mühling* could also find no Anthrax bacilli in smears made with the blood taken from the leeches, nor could he succeed in growing any bacilli in cultures from the same. *Mühling* did see some streptococci in the blood of the leeches, but these were of low virulence. He believes that the low temperature of the leech is not suitable for the growth of streptococci in the body of the leech. *Mühling* came to the conclusion that pathogenic bacteria are not transmitted through the bite of the leech. He also states that the envirement in the intestine of the leech is apparently not suitable for the growth and propagation of pathogenic bacteria.

In regard to the possible transmission of the Treponema pallidum through the leech it is difficult to see how an organism that is so highly adapted to the temperature and the body juice of man and a certain higher vertebrates can possibly exist for any length of time in the leech. Cases of transmission of syphilitic infection through leech use have not been reported in literature.

The medicinal leech is a comparatively rare animal. In the first half of the last century all available statistics (*Moquin-Tandon*) show that millions of the animals were used yearly. *Moquin-Tandon* estimates that in France alone between 20 and 30 million leeches were yearly used between 1830 and 1840. Such extensive use of leeches led to their practical extermination in

western Europe. *Moquin-Tandon* in his monography describes a number of varieties and gives some excellent representations of the these in color. A good many of these varieties are not found today in Europe. The leech has a life span which may attain 20 years (*Moquin-Tandon*). Leeches that are suitable for use in therapy are at least 5 years old. Also they do not propagate themselves before they have attained full maturity, which in most cases also takes 5 years. If the use of leeches should become prevalent in the United States, as it may be expected to do some day, the danger exists that these animals could be exterminated if they are killed after their use. In case in the opinion of the physician a leech once used is not to be used again, then the leeches, that have been used by that physician in the therapy of patients, should be either used for breeding purposes or he should take the trouble to release the animals in some locality, where it may be assumed that they would have a chance to exist and propagate themselves (*Moquin-Tandon*).

A leech that has been used should not be applied again before six months have elapsed. Six months time should be sufficient for any pathogenic bacteria or other organisms to have died in the body of the leech.

The reason for the comparatively sudden abandon of the leech therapy, which set in shortly after 1850, was the result of an excessive, frequently dishonest or charlatan type use of the same. The indications for their use also lacked the necessary precision.

Zusammenfassung

In einem historischen Überblick wird die Entwicklung unserer Kenntnisse über den anatomischen Bau des Blutegels und dessen zoologische Systematik verfolgt. Im anatomisch-physiologischen Teil wird eine Darstellung des Nervensystems gegeben, wobei die Segmentierung des Tieres als Grundlage dient. Bei Besprechung des Gefäßsystems wird gesagt, daß die Muskulatur der Seitengefäße sich abwechselnd zusammenzieht und erschlafft, wodurch das Blut des Blutegels in Bewegung gehalten wird.

Es wird die zentrale Stellung der Leber im menschlichen Körper gewürdigt. Die Leber wird durch die Sérégé-Cantlie-Linie, die von der Gallenblase zur Mündungsstelle der Lebervenen in die untere Hohlvene verläuft, in eine rechte und eine linke Hälfte geteilt: die linke Hälfte der so geteilt gedachten Leber bezieht ihr Blut zur Hauptsache aus Magen, Milz und Pancreas, wogegen die rechte Hälfte enge Beziehungen zum Darm, insbesondere aber zum Caecum samt Appendix hat. Die Leber beeinflußt die Tätigkeit der Nieren, anderseits hat der Zustand der Nieren Rückwirkungen auf die Leber. Die verschiedenen Zonen der Leber und die diesen Zonen entsprechenden Organe beeinflussen sich gegenseitig. Die lebensrettende Wirkung des Ansetzens einer großen Zahl von Blutegeln in der Leberzone bei Leberschwellungskrisen bestimmter Art und Ursache wird erwähnt.

Die Erfahrungen der Basler Chirurgischen Klinik zeigen, daß bei Phlebitis, Phlegmonen, Conjunctivitis catarrhalis acuta, Otitis media acuta und Mastoiditis der Gebrauch von Blutegeln gute Wirkung hat. Bei der Thrombose ist zu unterscheiden, ob die blande, liederlich aufgebaute und sich rasch entwickelnde oder ob die phlebitisch-periphlebitische, geordnet sich aufbauende und langsam sich entwickelnde Form vorliegt. Der Nutzen der Blutegelbehandlung ist bewiesen für gewisse spontane und postoperative Thrombosen, im wesentlichen jener phlebitischen Ursprungs. Der Erfolg der prophylaktischen Anwendung von Blutegeln zur Minderung von postoperativen Thrombosen ist mitabhängig von den so verschiedenen Ursachen der Thrombose und den Zufälligkeiten ihrer embolischen Verschleppung. Nützlich sind sie im präthrombotischen Stadium bei Patienten, die eine Venenentzündung haben. Dabei darf nicht vergessen werden, daß der prophylaktische Gebrauch von Blutegeln eine erhöhte Blutungsbereitschaft bedingt, so daß die Gefahr einer postoperativen Nachblutung besteht, dies besonders bei der Prostatektomie und anderen Operationen im kleinen Bekken. Auch bei jenen Thrombosegefährdeten, die prophylaktisch mit Heparin behandelt werden, ist zusätzliche Anwendung von Blutegeln nützlich, da der Blutegelbiß wegen seines Hirudingehalts nicht nur gerinnungshemmend, sondern dazu noch antiseptisch und krampflösend wirkt, womit sich die vasculäre Krampffesselung des Blutstromes löst.

Aus den in der Literatur angegebenen Statistiken läßt sich keinesfalls ersehen, wie dies im Anfang der Wiederaufnahme der Blutegelanwendung von einigen Autoren behauptet wurde, daß ihr Gebrauch zu einer Häufung der Embolievorkommnisse führe. Die Blutegelbehandlung ist indiziert bei der auf einer entzündlichen Grundlage sich langsam entwickelnden, schmerzhaften Thrombose; bei diesen ist die Emboliegefahr gering. Die statistischen Tabellen, die das Resultat der Erfahrungen über den Gebrauch von Blutegeln bei post partum auftretenden und postoperativen Thrombosen darstellen, geben leider nicht an, um welche Art von Thrombose es sich handelte, bei denen es zur Embolie gekommen ist.

Der verhältnismäßig plötzliche Verzicht auf die Blutegeltherapie kurz nach 1850 war die Folge der vorangegangenen, oft charlatanmäßigen, übertriebenen und zu wenig auf bestimmte Anzeigen gestellten Anwendung.

Aus der Literatur werden Fälle von erfolgreichem Gebrauch bei Phlegmonen, bei Migräne und bei Glaukom gebracht. Bei Thrombose läßt der Schmerz rasch nach unter Rückgang der postthrombotischen Weichteilschwellung.

References

Aetius, Amidenus: Sermo 1, cap. 56, de Ioanne Baptista Montano. Basilea, 1533. – *Aldrovande, Ulysses:* De Animalibus, insectis etc. Lib. VII, p. 725, Bononiae, 1638; also other editions. – *Antyllus:* see Daremberg, Œuvres d'Oribase **II,** 69, Paris, 1854. – *Apathy, St.:* Die Analyse der äusseren Körperform der Egel. Mitteilungen aus der

zoologischen Station zu Neapel. Vol. 8, p. 153, Leipzig, 1888. – *Aretaeus:* In Medicorum Graecorum Opera quae extant by C. G. Kühn. Vol. XXIV, Lipsiae, 1828. Therapeutics of acute diseases Biblion B, chap. 6 (therapy of acutely affected liver), p. 275, chap. 11, p. 290 (treatment of satyriasis). – *Arnaldus de Villanova:* Collectio ophtalmologica veterum Auctorum, by P. Pansier, Paris, 1903. Opus praeclari magistri Arnaldi de Villanova nova impressi etc. Lugduni, 1504. Fol. 104–128. Parables of the healing Art of Arnaldus of Villanova. Translated into German by Diepgen, Paul, Leipzig, 1922. 4th Doctrine, chapter 2; also the Breviarium practicae. – *Aschner, Bernhard:* Lehrbuch der Konstitutionstherapie, 5th ed. Stuttgart, 1933; Münch. med. Wschr. **76,** 1379 (1929). – *Baster, J.:* Opuscula subseciva, Harlem. Tome **1,** lib. 2 (1760). – *Beddard, F. E.:* Trans. Roy. Soc. Edinburgh **35** (1889). – *Best* and *Taylor:* Physiological Basis of medical Practice. 4th ed. Baltimore, 1945, p. 286. – *Bibiena, F.:* De Hirudine sermones quinque. Comment. Inst. Bonon. 1791, tome 7, p. 55. – *Bing, Robert:* Chapter on Apoplexy, in Textbook of Neurology. Numerous editions in various languages. – *Blainville:* Dict. scienc. nat. Article Sangsue. Tome **47** (1827) and tome **57** (1828). – *Blanchard, R.:* Boll. Musei Zoolog. ed Anat., Torino, **9,** No. 192 (1894). – *Bochart, Samuel:* Hierozoici sive bipartiti operis de animalibus S. Scripturae, pars posterior libris sex. Liber V. Caput XIX, p. 796. Lugduni batavor. "de Sanguisuga". Also printed in London 1663. Lugd. batv. 1692. – *Bojanus, L. H.:* Isis, 1827. Heft 7, p. 881; 1818, Heft 12. – *Bosc:* Nouv. Dict. d'Hist. nat. Article Sangsue, **30,** 137 (1819). – *Bottenberg:* Die Blutegelbehandlung. Med. Welt **9,** 647 (1935). – *Brandt, J. F.,* und *Ratzeburg:* Medizinische Zoologie. Berlin, 1829. – *Bruck, F.:* Wien. med. Wschr. **93,** 422 (1943). – *Brumpt, E.:* C. r. Soc. Biol. **60,** 160 (1906). – *Caelius Aurelianus:* Chron., Lib. 1, cap. 1, § 48; lib. III, cap. 4; lib. V, cap. 1. – *Carena, H.:* Mem. reale acad. sci. di Torino. Torino, 1820. – *Cassius, Felix:* cap. 21, "ad empyemata", 7–22. – *Castle, W.E.:* Bull. Museum comparat. Zoology at Harvard Coll., Cambridge (U.S.A.) **36,** 17 (1900). – *Castle, W.L.:* Proc. Amer. Acad. Arts a. Sci. **35,** 285 (1900). – *Celsus:* Liber V, cap. 27, § 16. "Si sanguisuga epota est, acetum cum sale bibendum est". "De medicina libri octo". Ed. Almeloveen. Basilea 1748. – *Charpentier, A.:* Monographie des sangsues médicinales et officinales. Paris, 1838. – Compendium *Roche,* Basel, 1948. – *Craig* and *Faust:* Clinical Parasitology. 4th ed. Philadelphia, 1945. p. 533. – *Cuvier, G.:* Leçons d'Anatomie comparée. Paris, 1800–1805. 5 vols; Histoire des Sciences naturelles. Par Madeleine de Saint-Agy. Paris, 1841. – *Dantec, Le, A.:* Précis de pathologie exotique, 5th ed. Paris, 1929. – *Daremberg:* Dictionnaire des Antiquités. See under Hecate, in that vol. pp. 48–49. Paris, 1899. Œuvres d'Oribase. Tome 11. Paris, 1854. – *Dillenius, J.J.:* De Hirudine. Nuremberg, 1719. – *Dutrochet:* Note sur une Annelide d'un genre nouveau. Bulletins de la Soc. Phil., Paris, 1817. – *Galenus, C.:* Claudii Galeni Opera Omnia, transl. by Carl Gottlob Kühn. Leipzig, 1828–1833. 20 vols; vol. **11,** 317, 318 use of leeches; vol. **8,** p. 265; vol. **16,** p. 477, ingested leeches. Remedies for swallowed leeches in vol. **14,** pp. 143, 440, 538 and 576. Index in vol. **20.** Galieni Opera, per Philippum de Monardi, Physici. Brixensis, 1490. – *Gesenius:* Hebräisches und Chaldäisches Handwörterbuch über das alte Testament. Leipzig, 1823. – *Gesner, Conrad:* Nomenclator aquatilium animantium natura. Tiguri, 1560. – *Hahn, P. F., Donald, W. D., Grier jr., R.C.:* Am. J. of Phys., Vol. 143, No. 1, Jan. 1945. – *Heisler, A.:* Münch. med. Wschr. **83,** 130 (1936). – *Henschen, Carl:* Arch. klin. Chir. **152,** 103 (1928) (use of leeches as prophylactic measure to reduce incidence of thrombosis); **167** (1931) (crises of swelling of the liver); **173** (1932) (importance of the liver in surgery). – *Herder:* Geist der hebräischen Poesie. Vol. **11,** p. 284. – *Hill, J.:* Gen. nat. hist., London 1748 to 1752. 3 vols. – *Home:* Lectures on comparative anatomy. London, 1814–1828. 6 vols. – *Höppli, R.,* and *Tang, C.C.:* Chin. med. J. **59,** 359 (1941). – *Huber, J. Ch.:* Dtsch. Arch. klin. Med. **47,** 522 (1891). – *Johannes Actuarius:* Lib. V, cap. 12

(Hirudo epota). Actuarius de medicamentorum compositione. Ioannes Ruellio interpretit. Basileae 1540. – *Johansson, L.:* Bidrag till kännedomen om Sveriges Ichthyobdellider. Akademisk Afhandling af Filosofiska Fakulteten vid Upsala. 1896. – *Johnson, J. R.:* A treatise on the medicinal leech, including it's medical and natural history with a description of it's anatomical structure. London, 1816. – *Keating, William H.:* Narrative of an Expedition to the source of St. Peter's River, Lake Winnepeek, Lake of the Woods, etc., Majors' Long second Voyage. Philadelphia, 1824. Vol. II, p. 150. – *Klapp, R.:* Zbl. Chir. **59,** 840 (1932). – *Kocher, Theodor:* Chirurgische Operationslehre, 5th edition, p. 821 (hepato-cholangio-enterostomia). Jena, 1907. – *Kowalewski, A.:* Mém. Acad. Imper. Sci. St. Petersbourg. Serie 8, tome **11,** No. 1, p. 1 (1900). – *Lamarck, J.B. de:* Histoire naturelle des animaux sans vertèbres. Paris 1818, tome **5,** p. 289. – *Lane, W.E.:* Meaning of Aluka or Alaka, Arabic-english Lexicon. London, 1874. Book I, part 5, p. 2132–2138. – *Leach, W.E.:* Pontobdella. The zoological miscellany. London, tome **2,** p. 9 (1815). – *Lenggenhager, K.:* Schweiz. med. Wschr. **66,** 227 (1936). – *Liebich, L.:* Arch. klin. Chir. **197,** 723 (1930). – *Linnaeus, C.:* Fauna Suecica, Stockholm 1746 and 1761. Systema naturae ed. X, Holmiae, 1758; ed. XII, Holmiae, 1767. – *Leuze, A.M.:* Münch. med. Wschr. **83,** 315 (1936). – *Lindemann, B. A.:* Arch. exper. Path. **193,** 490 (1939). – *Lucian:* Luciane Somosetensis Opera, graece latine. Johann Peter Schmidius. Mitaviae 1776–1880. Ver. hist. 11, 46; also Harmon, A.M., in 8 vols. New York, 1919. – *Mahorner, H.R.,* and *Ochsner, A.:* Ann. Surg. **98,** 408; Arch. Surg. (Am.) **31,** 308 (1935); **31,** 371 (1935). – *Marcellus Empiricus:* De medicamentis, cap. 7 § 11; cap. 8, § 184. – *Mayor, F.:* Analyse critique de la Monographie des Hirudinées de A. Moquin-Tandon. Bibl. univ. Genève, tome **25,** May 1827. – *Menemachus:* see Oribasius. – *Meyer, O.:* Internat. Bull. med. Res. 5 Publ. Hygiene Assoc. **44,** 4 (1944); Münch. med. Wschr. **85,** 827 (1938) (in idiopathic trigeminus neuralgia). - *Moquin-Tandon, A.:* Monographie de la Famille des Hirudinées. 2nd ed. Paris, 1846. 1st ed. Paris, 1826. – *Moore, J. P.:* Proc. U.S. National Museum, Washington, **21,** 543 (1898); Puerto Rico J. publ. Health **14,** 422 (1939). – *Mühling, Paul:* Diss., Königsberg, 1899. – *Muralto de, J.:* Vademecum Anatomicum seu clavis medica. Tiguri, 1673. – *Morand:* Observations sur l'Anatomie de Sangsue. Hist. acad. royale sciences. Paris, 1739. – *Oberheid, L.:* Münch. med. Wschr. **87,** 942 (1940). – *Odier, A.:* Mém. soc. d'hist. nat. Paris **1,** 69 (1823). – *Oribasius:* Ed. Daremberg. Paris, 1854. – *Paulus of Aegina* II. § 44. Curatio doloris capitis. – *Paracelsus:* dessen Bücher und Schriften. Published by J. Huserum, Basel, 1589. – *Pinto, C.:* Ensaio monographico dos Hirudineos. Revista do Museo Paulista. Vol. **13,** 857, São Paulo, 1923. – *Plinius, C.:* XXX. cap. 67, 76, 136. Naturalis historia. lib. VIII, cap. X, § 3; lib. XXXII, cap. VII, § 9; cap. X, § 9. – *Price:* A treatise on the utility of sanguisuction or leechbleeding, etc. London, 1822. – *Ray, J.:* Historia Insectorum. London, 1710. – *Redi, F.:* Osservatione intorno a gli animali viventi che si trovano negli animali viventi. Firenze, 1684. – *Roesel, von Rosenhof, August Johann:* Der monathlich herausgegebenen Insecten Belustigung, dritter Theil. XXX, 2. Der Fischegel nebst seiner Verwandlung. p. 199. – *Rössle, R.:* Virchows Arch. **300,** 180 (1937); *Rondelet:* De piscibus, liber de palustribus, cap. IX, p. 226; liber de insectis et zoophytis, cap. VII p. 111. – *Say:* see Keating, W.H. – *Savigny, J.C.:* Système des annelides, principalement de celles de la côte de l'Egypte. Paris, 1820. – *Schreiner, K.:* Dtsch. med. Wschr. **61,** 1955 (1935). – *Schultens, A.:* Commentary of the Bible; proverb. hebraic. et lat. Lugdunum batavorum 1748. – *Sennert, Daniele:* Practicae medicinae liber tertius, pars II, sect. 11, cap. IX, p. 422. Use of leeches in hemorrhoids. Wittenberg. – *Scriban* and *Autrum:* Handb. d. Zoologie, herausgegeben von Krumbach. Bd. II, Teil 8, Bogen 16–22; Teil 8, Bogen 8–15. – *Simonis:* lexicon manuale hebraicum et chaldeicum, editio altera. Hallae Magdeburgicae, 1771. – *Staub, H.:* Arch. klin. Chir; see Henschen. – *Sulger* und *Bozsin:*

Dtsch. Z. Chir. **216,** 175 (1929). – *Theophanus Nonnus:* Epitome de curatione morborum. Gothæ, 1794–1795. Bernard. – *Thomas, P.:* Mémoires pour servir à l'histoire naturelle des Sangsues. Paris, 1806. – *Tibbles, Sydney:* Brit. med. J. **1935,** 785. – *Tremblay, A.:* Mémoires pour servir à l'histoire d'un genre de polypes d'eau douce, à bras. Paris, 1744. – *Volhard, F.:* Handb. Inn. Med. von Mohr u. Stæhelin Bd. 6, Teil II, p. 1320. 2nd ed. 1931. – *Vulpes, M.:* Illustrazione di tutti gli instrumenti chirurgici scavati in Ercolano et in Pompeii, etc. Napoli, 1847. – *Walzel:* Technik der Eingriffe am Gallensystem. Berlin, 1928. – *Waring* and *Lukis:* Remarks on the uses of some of the bazaar medicines and common medical plants of India. London, 1907. – *Weber, M.:* Monographie des Hirudinées Sud-Américaines. Thèse de la Faculté des Sciences Neuchâtel. 1915. – *Whitmann, C. O.:* Proc. Amer. Acad. Arts a. Sci. **20,** 76 (1884). – *Wimhöfer:* Z. Geburtsh. **117,** 397 (1938).